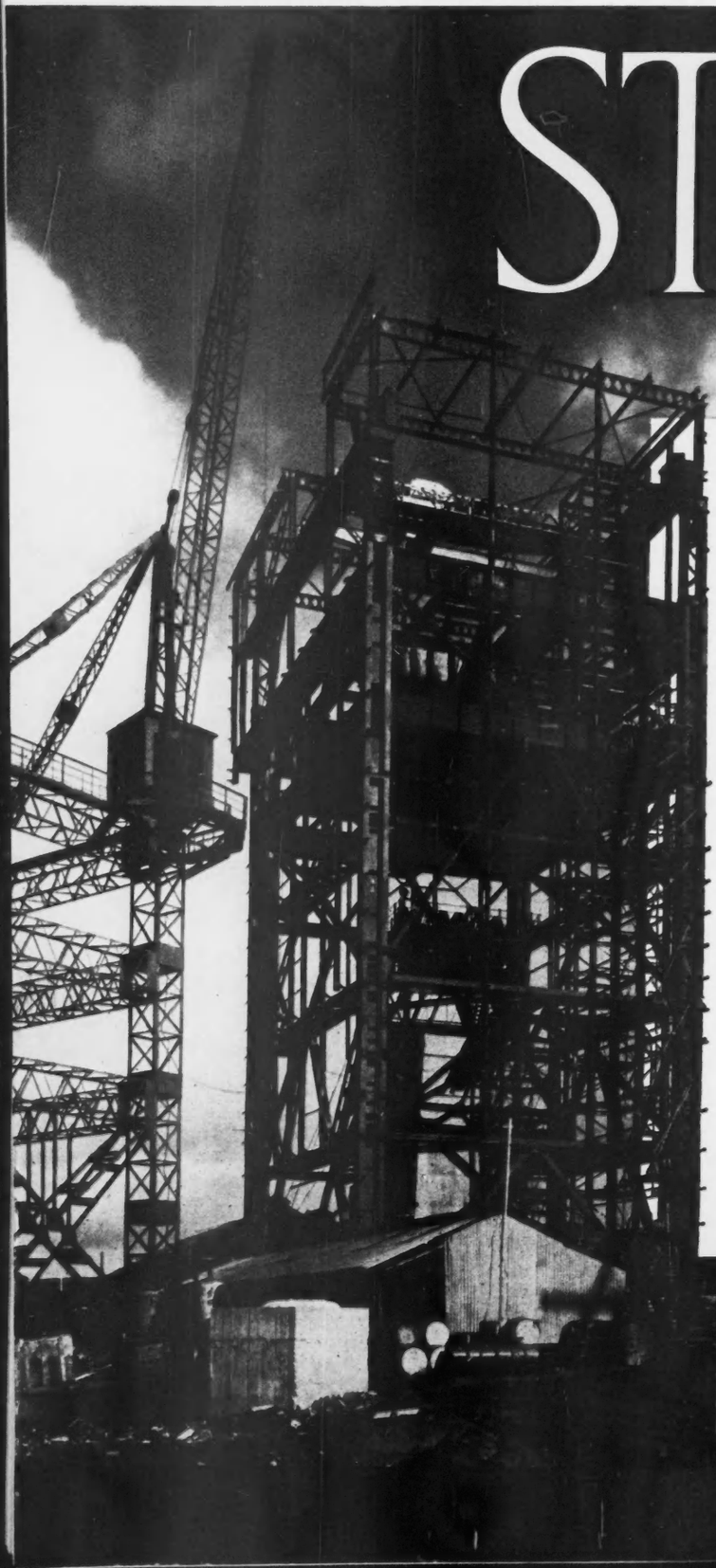
146

THE ENGINEER

MAY 29, 1959 | 28 ESSEX STREET, STRAND, LONDON, W.C.2 | TWO SHILLINGS

STEEL



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This winder tower is about 150 ft. high with columns at 60 ft. by 52 ft. centres.

Welded girders up to 15 tons in weight are used in the winder floor and motor generator floor. High-strength bolting was used for site erection, thus saving time.

The scotch derrick on the left is part of the contractor's erection tackle.

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The illustrations show the River Zambesi during the great flood early in 1958 ; and one of a number of large Glenfield free-roller direct-lift gates for flood control purposes on the River Tana, Kenya.

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THE ENGINEER

Established 1856

No. 5392 **MAY 29, 1959** VOL. 207

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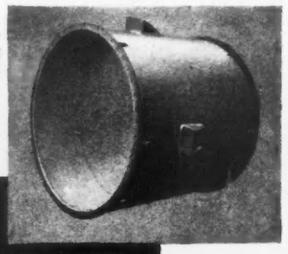

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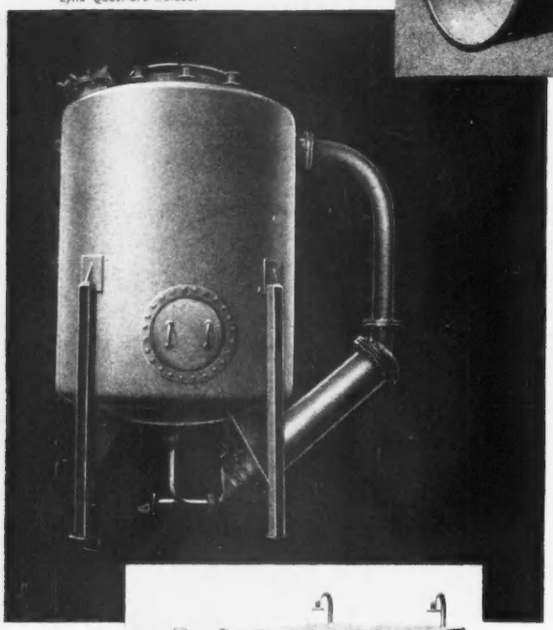

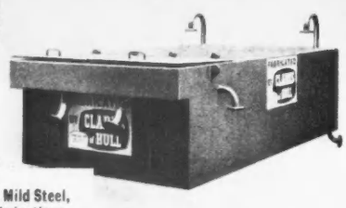

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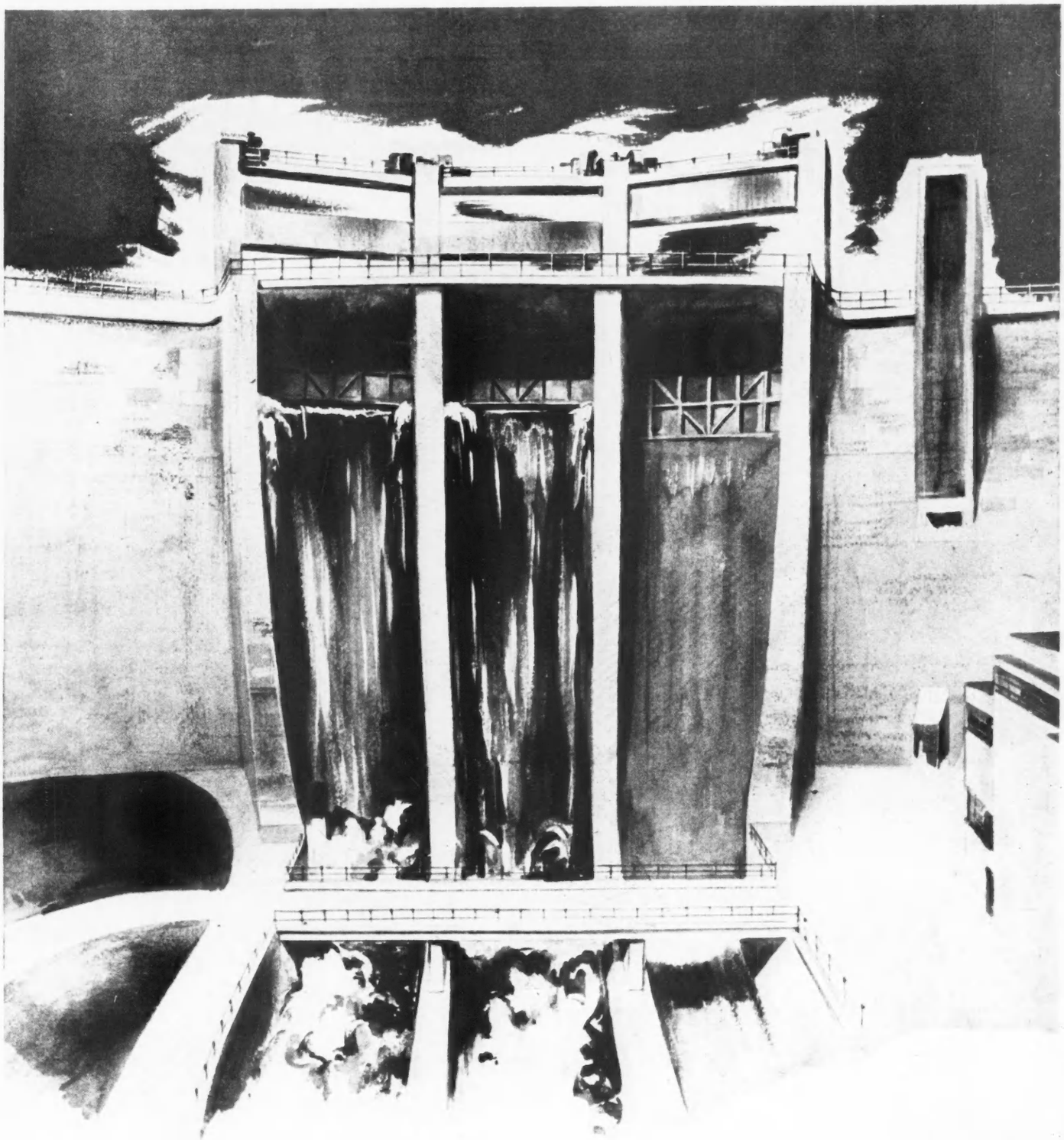

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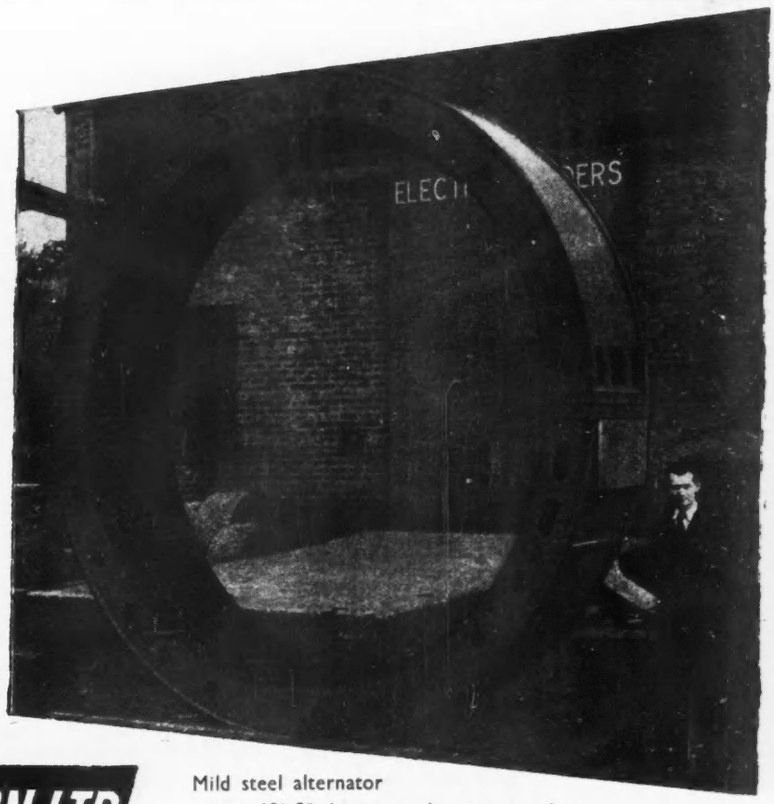

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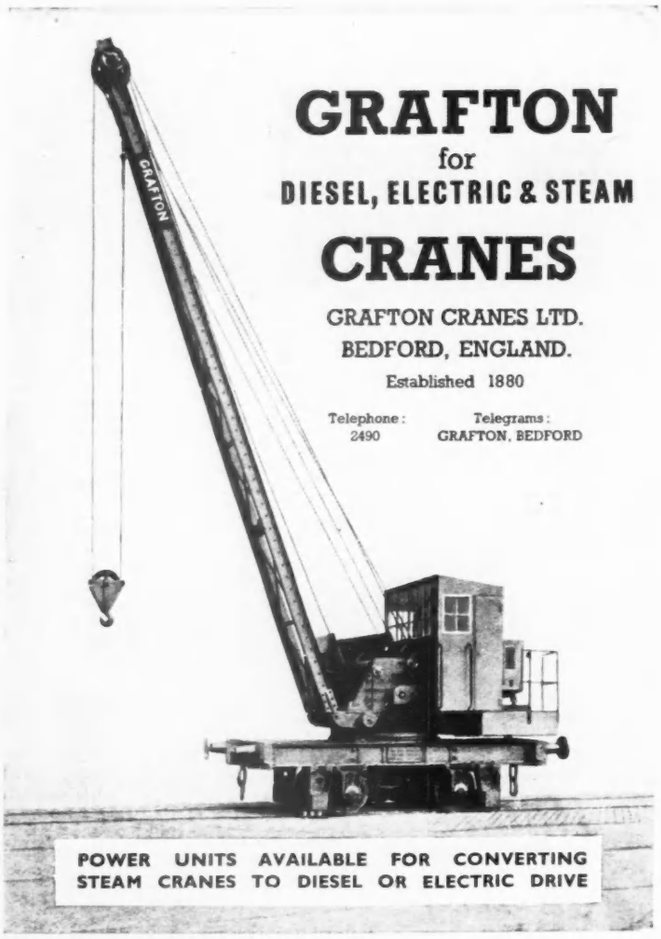

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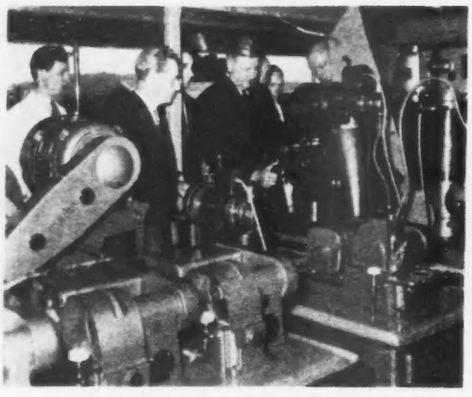

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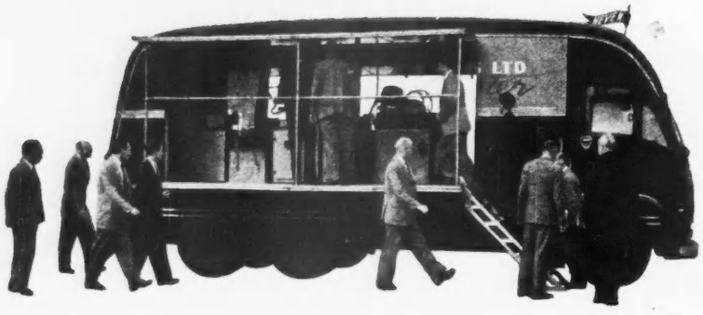

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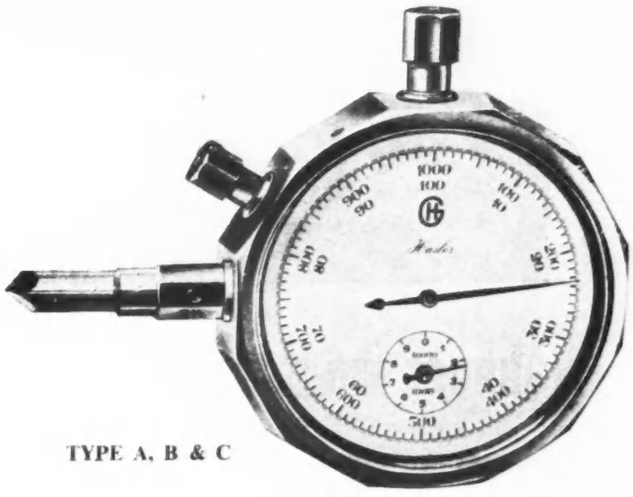

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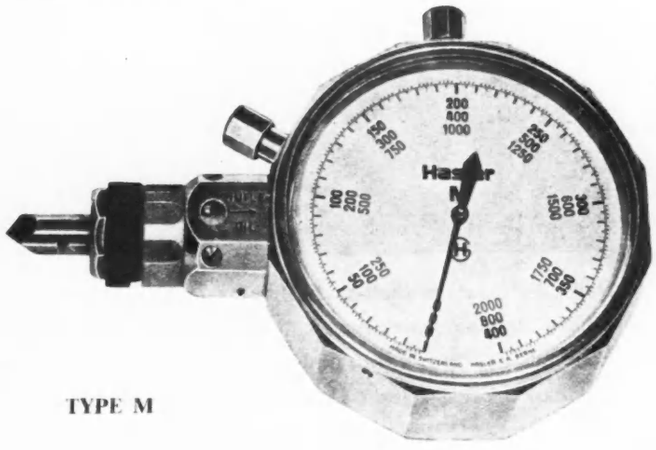

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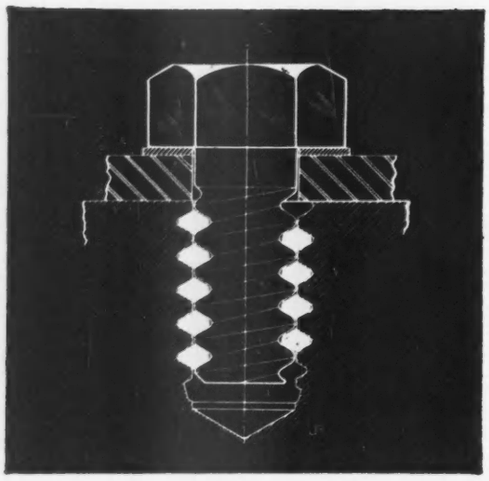

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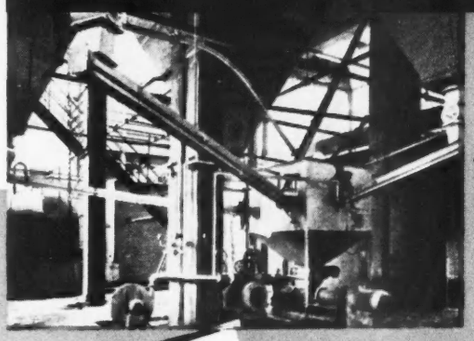

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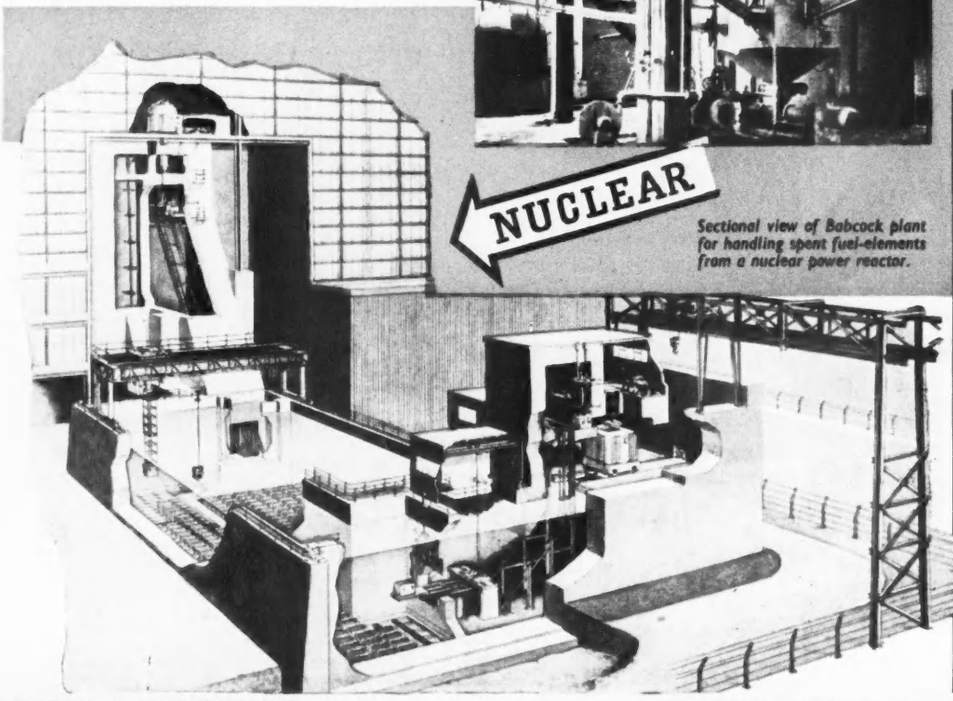

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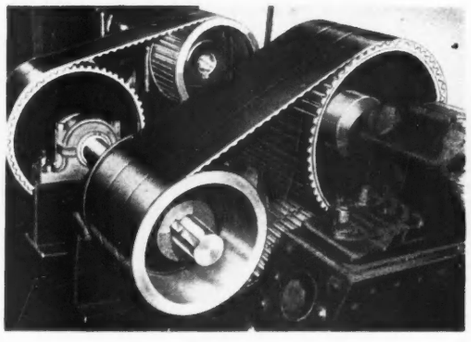
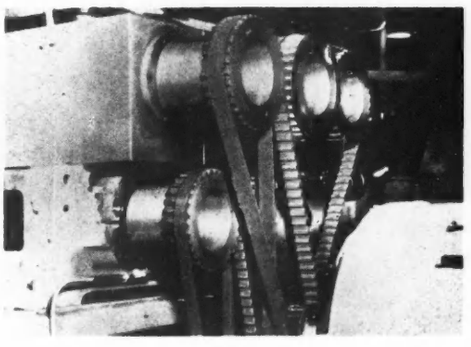


PowerGrip Timing Belts as an increasing gear on a dredge pump.



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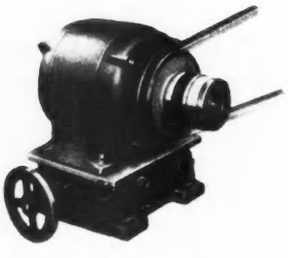

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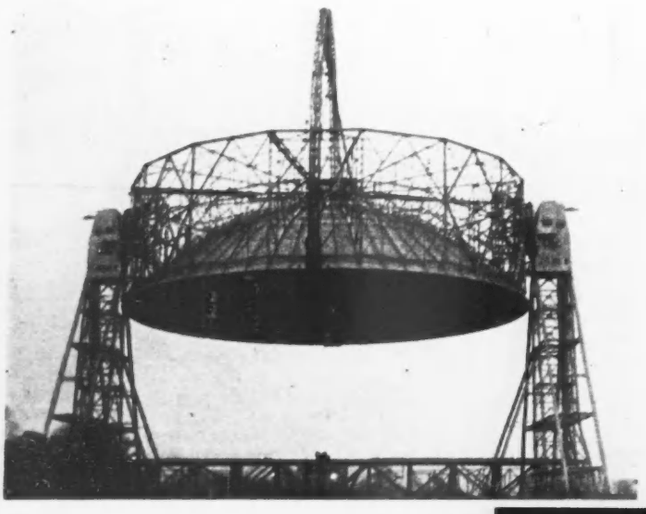

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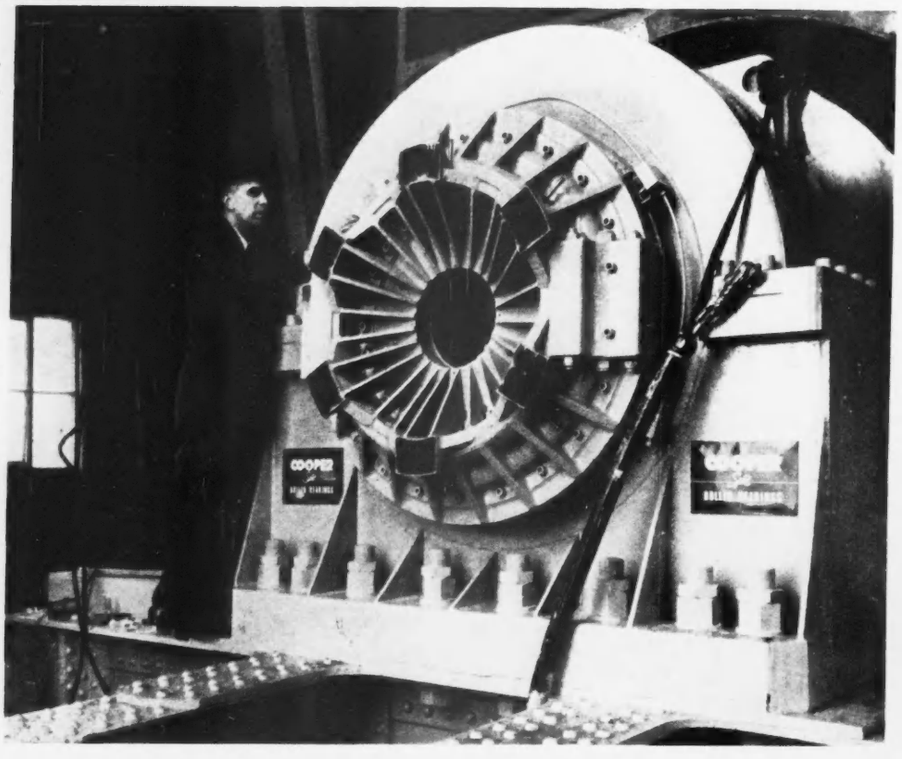

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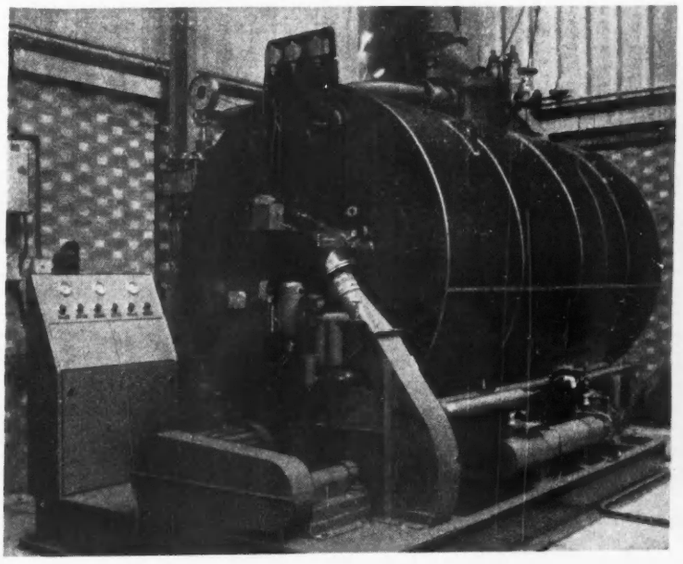
Patent No. 736020.

Brochure on application to



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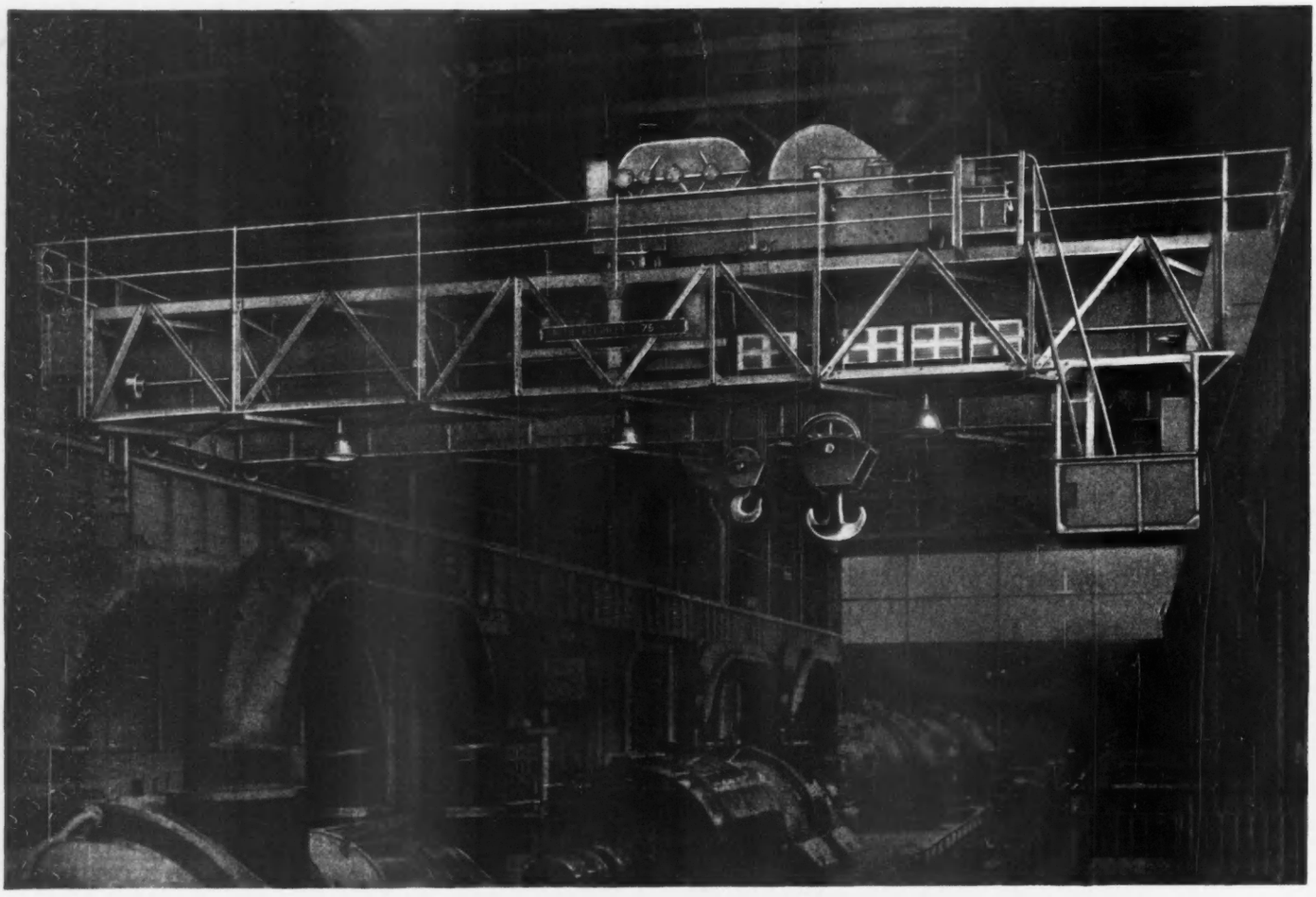

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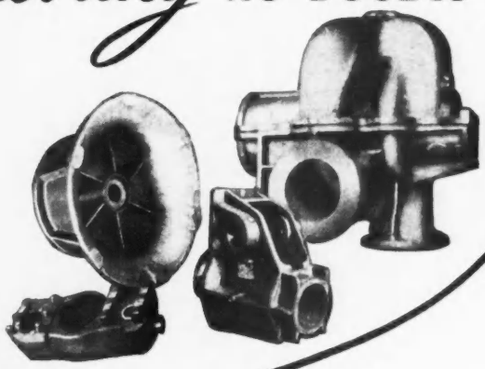

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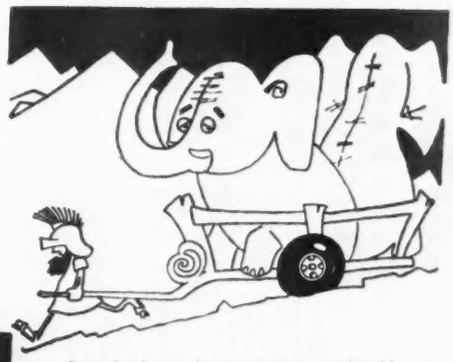

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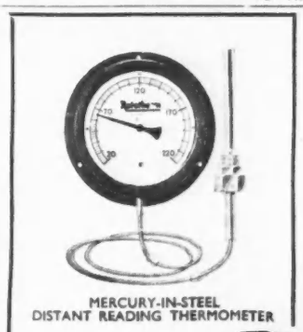

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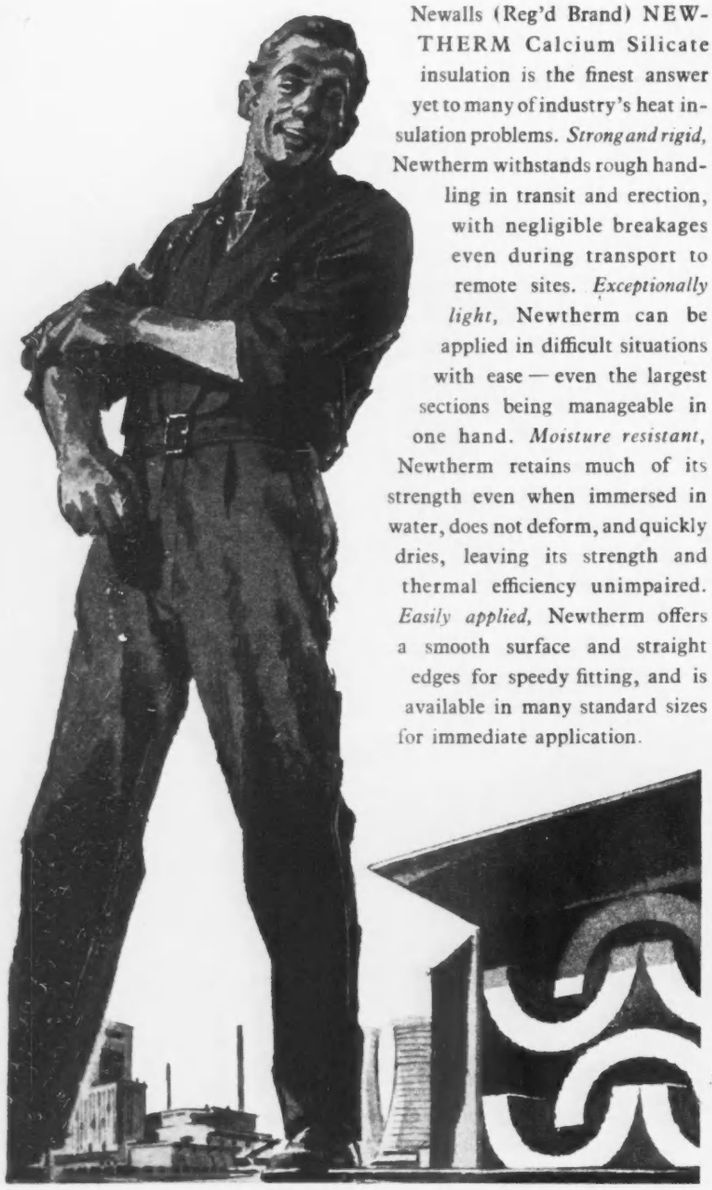

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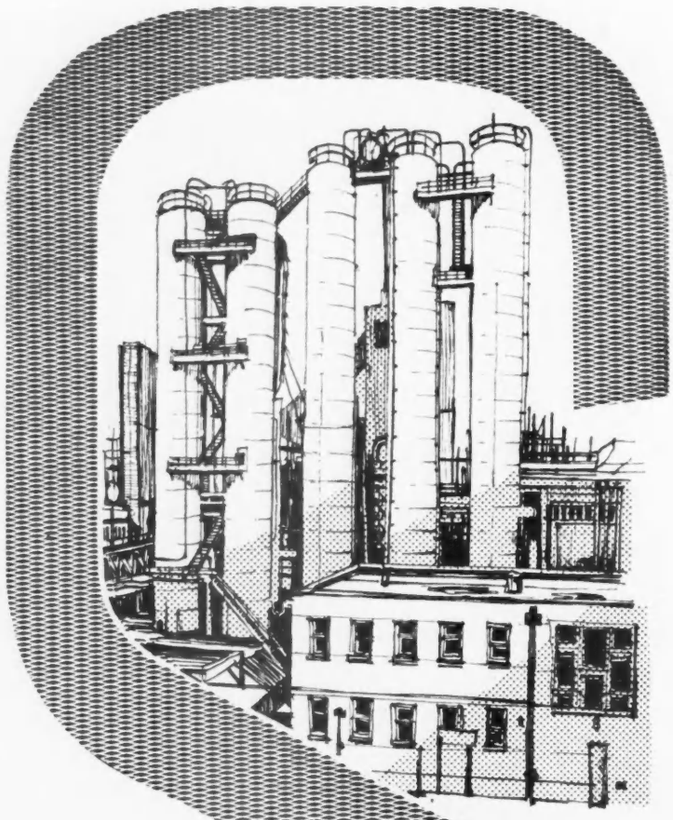

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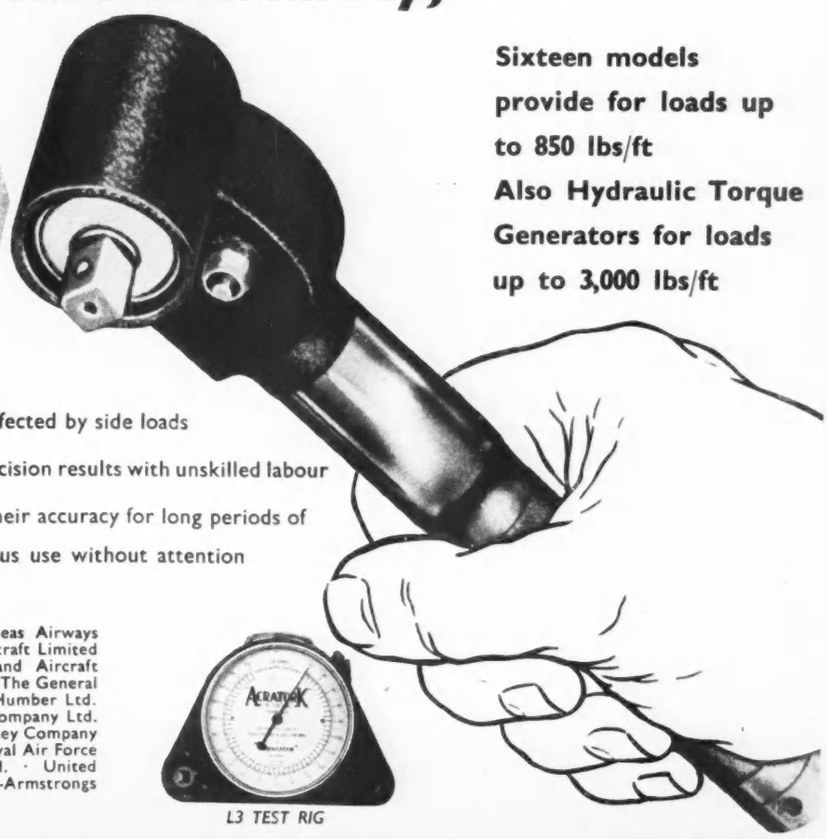

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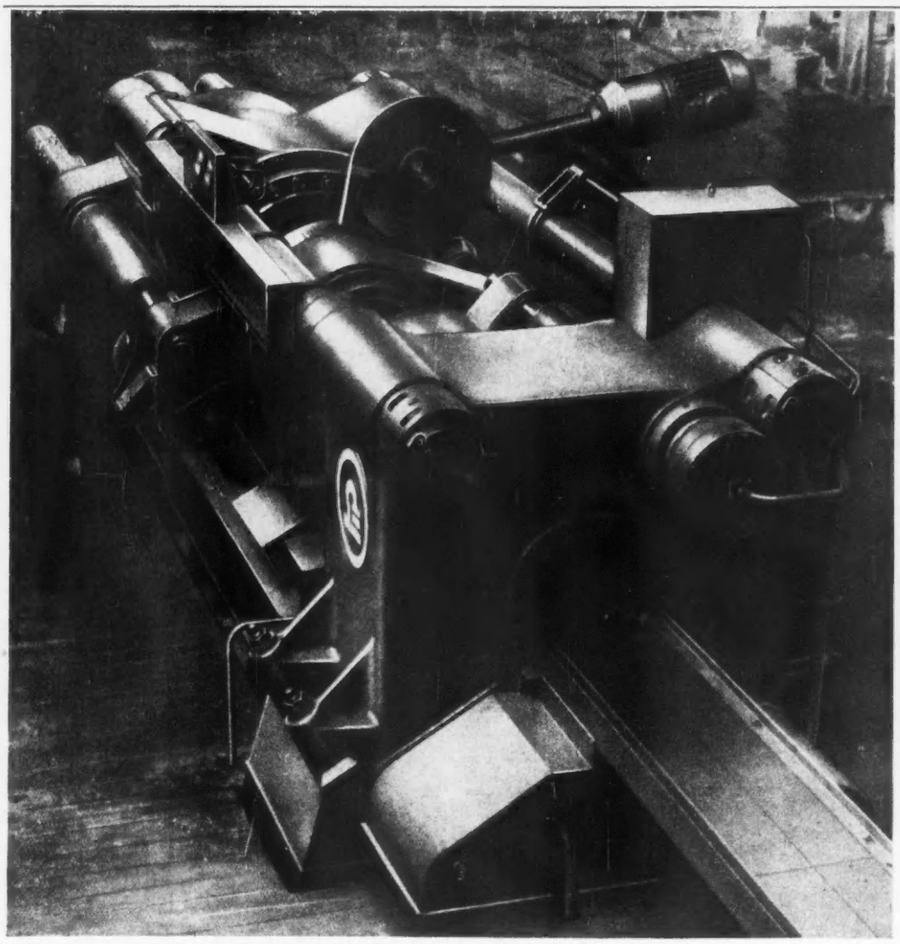

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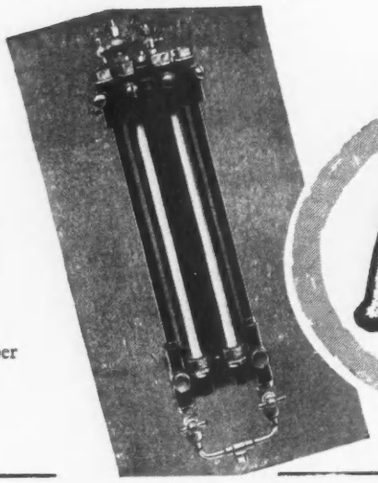

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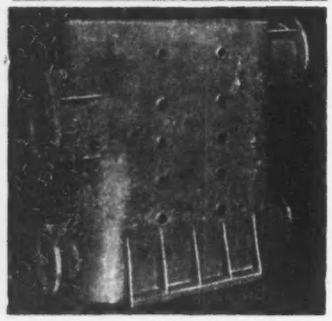

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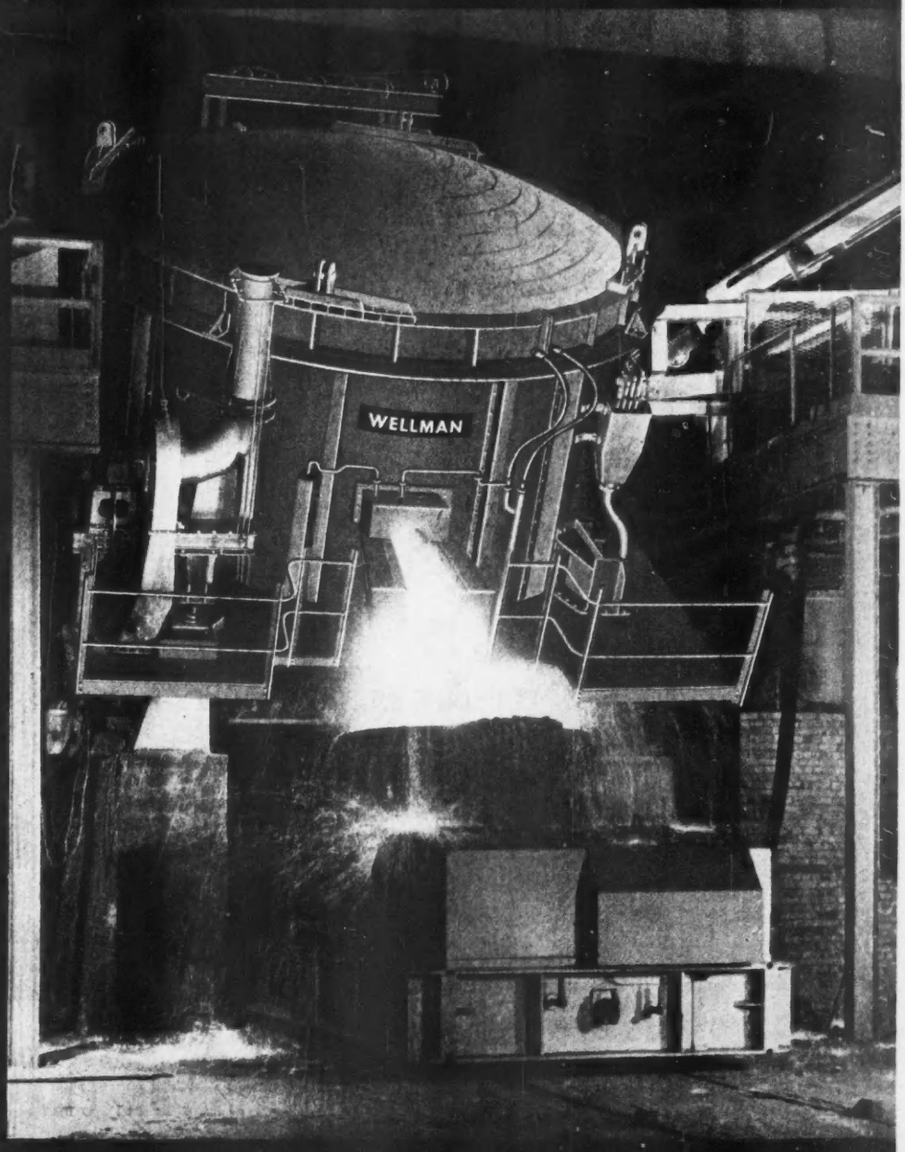

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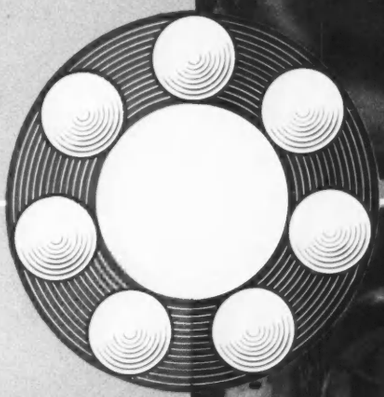

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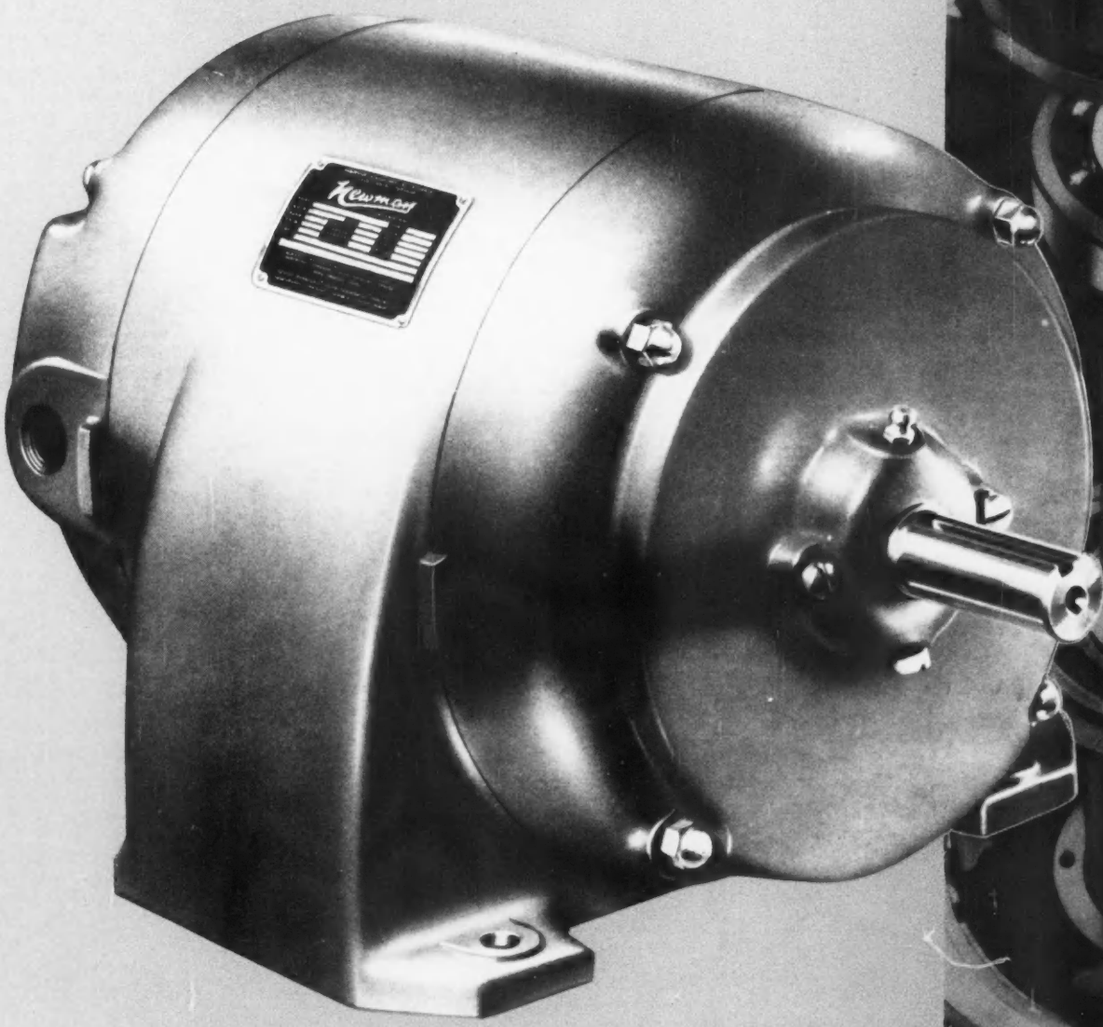

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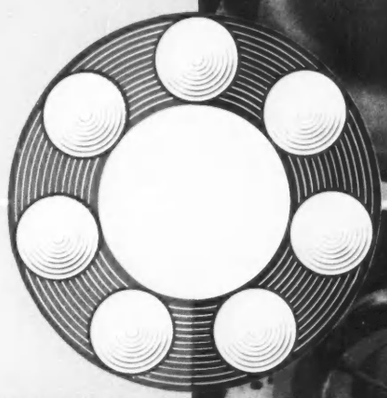

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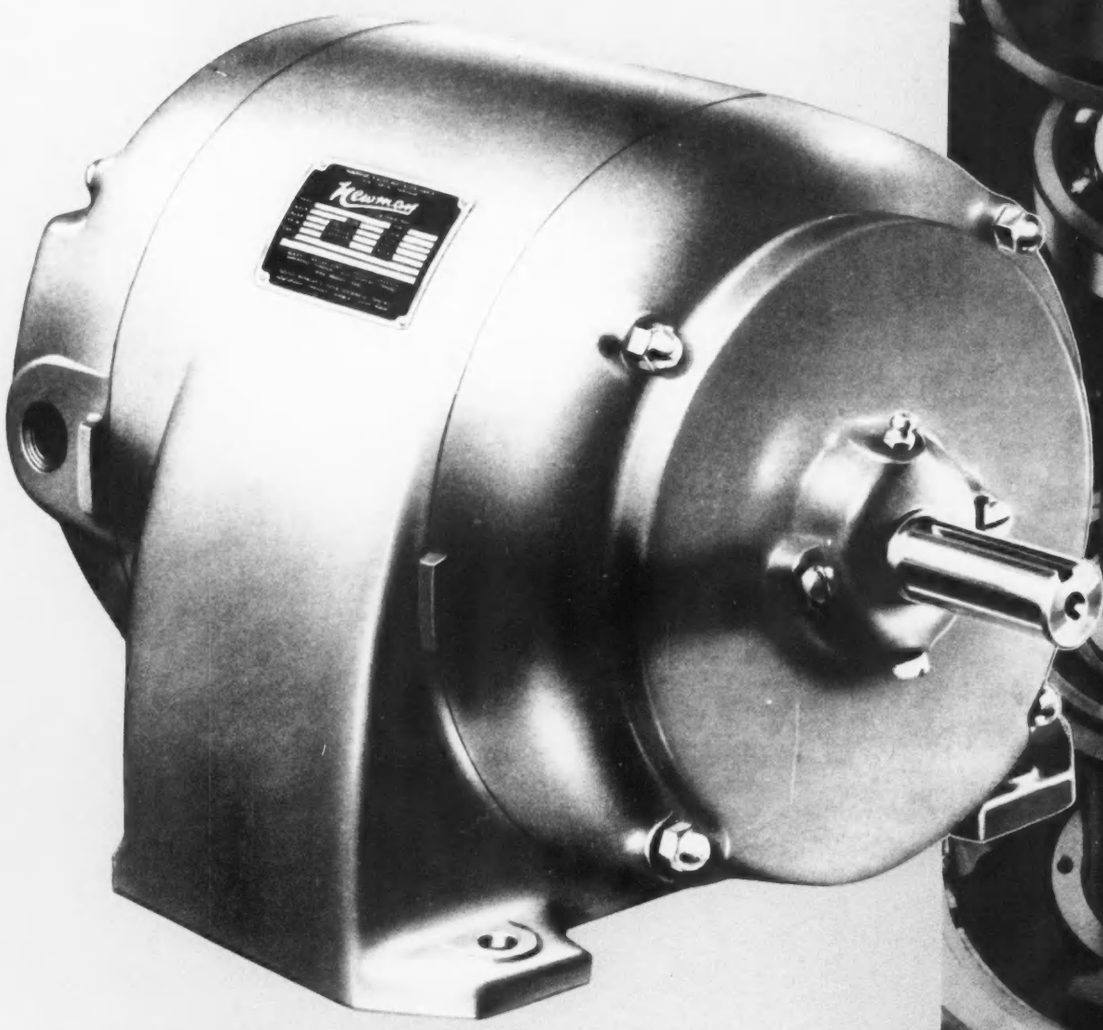

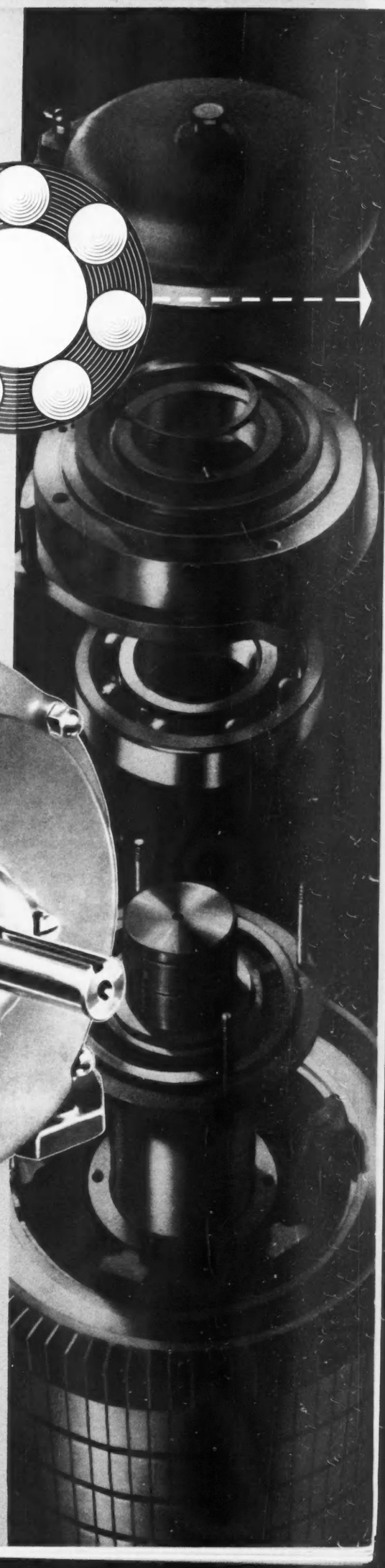

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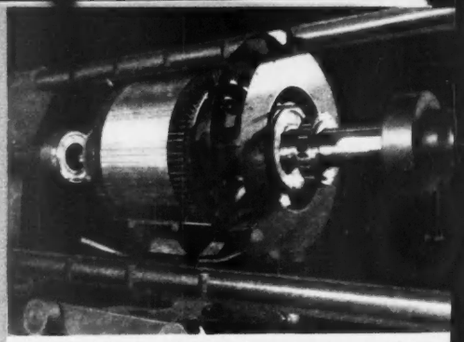
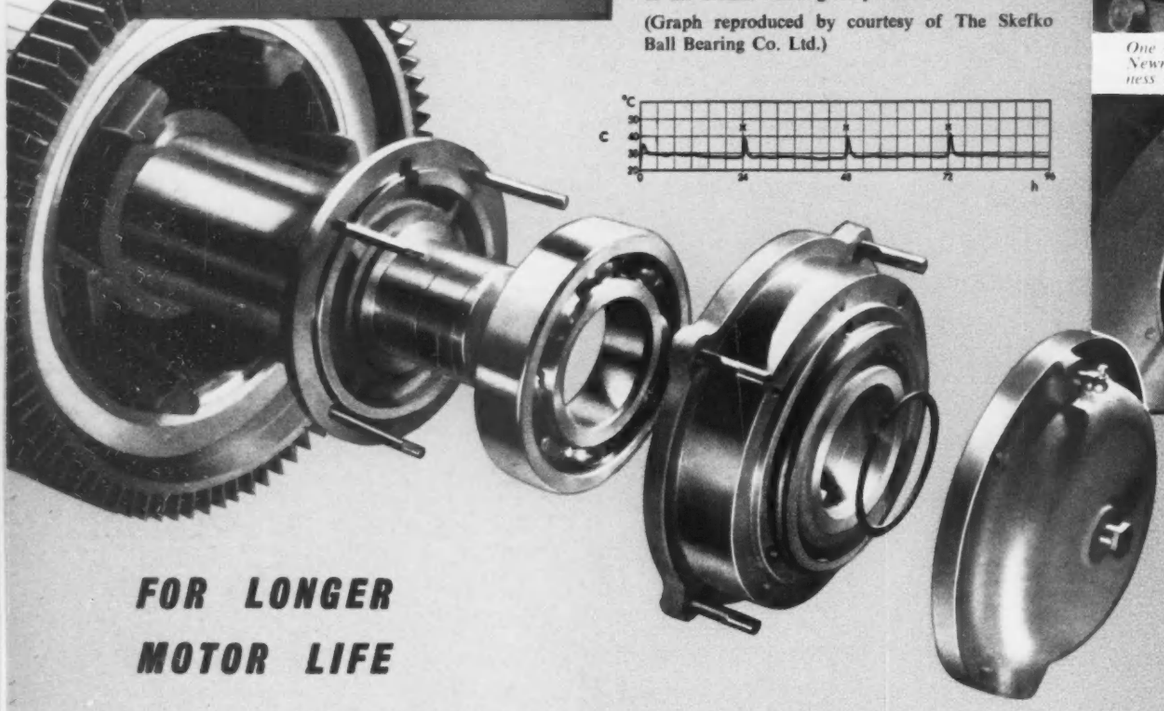
Newman BEARING DESIGN

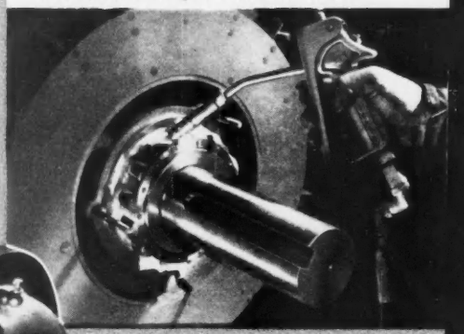
CONSTANT BEARING TEMPERATURES
This temperature graph obtained from a lubrication test shows that there is a slight increase in temperature at each lubrication (marked x) but the SKF grease escape valve ensures a rapid return to the normal running temperature.

(Graph reproduced by courtesy of The Skefko Ball Bearing Co. Ltd.)



One of the special hydraulic press set-ups used by Newman to ensure perfect alignment and squareness of the bearings on the rotor shaft.





Pressure grease dispensers ensure that clean grease is applied on to the moving parts during assembly . . .

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The thing to remember about Newman is that we are motor specialists. Our aim is always to advance electric motor standards beyond contemporary design by the use of better materials and new methods as soon as they are approved.

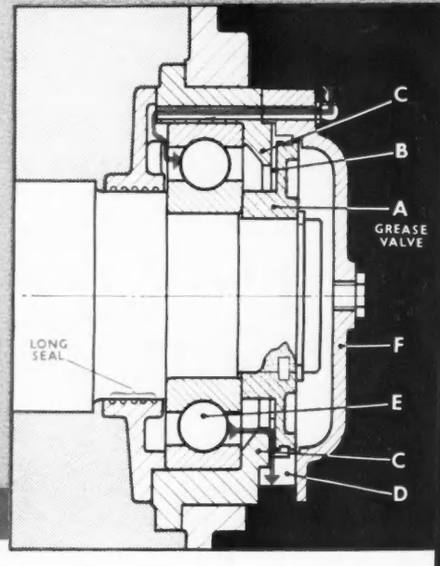
You always get something extra in a Newman motor. Take Newman bearing policy as an example:—considered under the three main headings of (a) Bearing Quality; (b) Bearing Housing and Fitting; (c) Provision for Maintenance.

(a) Only the leading makes of bearing to approved specifications for each application are used in Newman motors.

(b) Cartridge type housings standardised on larger motors completely enclose the bearings. Long, close fitting seals, exclude grit and retain grease. Precision boring of bearing housings, accurate gauging at every stage, and the use of special hydraulic presses to ensure proper alignment when fitting the bearings, ensure ideal conditions in which the bearings can operate.

In addition every rotor is balanced to eliminate uneven loads and where applicable bearings are lightly pre-loaded to ensure smooth running. (c) All bearings are packed with best quality grease under conditions of special cleanliness, and careful provision is made for subsequent regreasing. On larger Newman motors, where the size and speed necessitate more frequent re-greasing (with a consequent risk of over-lubricating) and where it is necessary to provide for re-lubrication while the motor is running, grease escape valves are fitted. These valves ensure correct lubrication regardless of the human element; as shown in detail on the right, they effectively eliminate the dangers of over-lubrication and the application of new grease automatically forces the old grease out of the bearing. An electric motor is no better than its bearings . . . in Newman motors the careful consideration given to bearing practice is a major factor in the search for longer life, unfailing power and greatest economy in operation.

POSITIVE COMPLETE LUBRICATION
Complete re-lubrication can be carried out without disturbing the bearings or stopping the motor. The drawing below shows how the SKF Grease Escape Valve fitted to larger Newman motors works. A disc (A) rotating with the shaft is located so as to leave a small gap (B) between the baffle (C) and the housing cap (F). Surplus grease coming into contact with the valve disc during or after lubrication is discharged through the grease outlet (D). It is therefore impossible to over-grease. This system automatically maintains the correct quantity of grease and ensures normal bearing temperatures—thus contributing to the reliable running of the whole motor.



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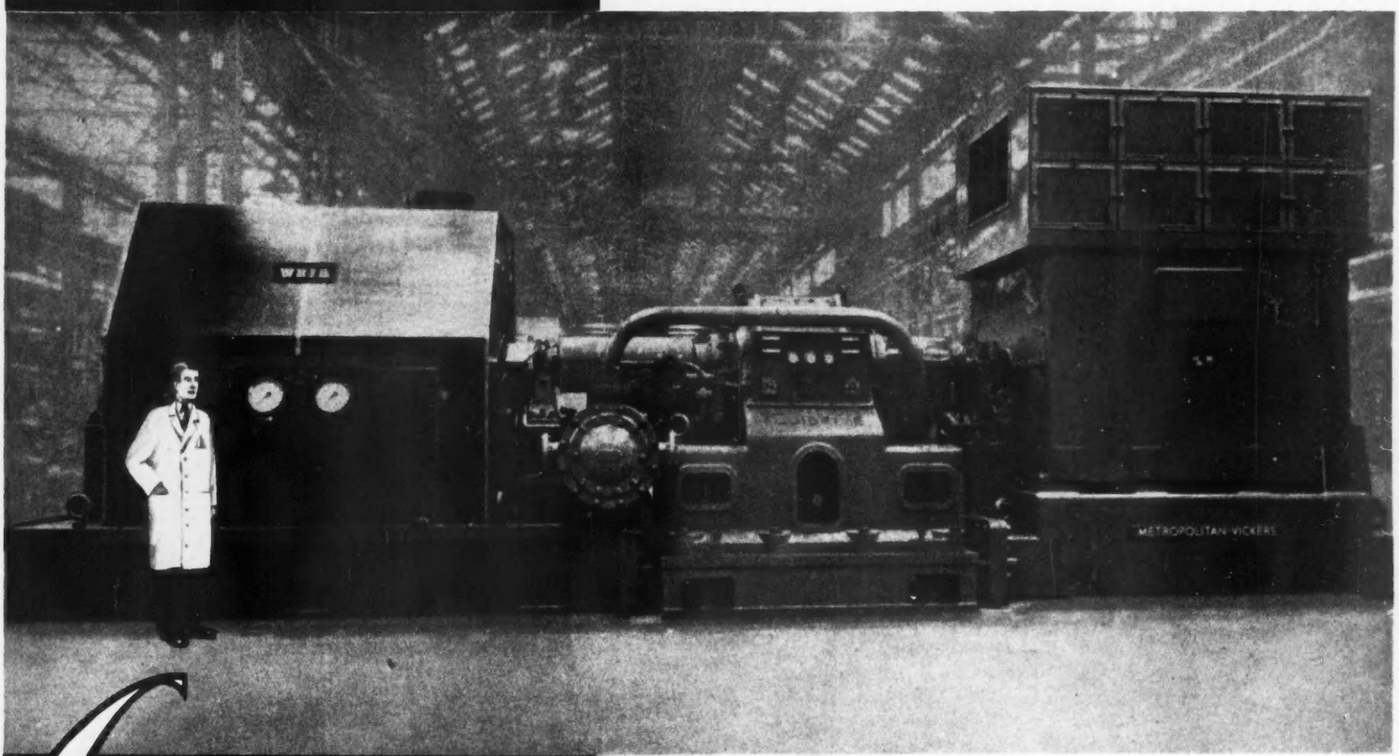

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This unit is one of six large Weir Electro-feed Pumps which are being supplied to the Hydro-electric Power Commission of Ontario, Canada, for their new Richard L. Hearn Generating Station. It is complete with 3,000 h.p. motor and variable speed fluid coupling. Its output is 735,000 pounds (328 tons) per hour, with a discharge pressure of 2,260 p.s.i. When installed, two of these pumps will be working together, with a third as a stand-by, in each of the two Power Station Units 6 and 7.

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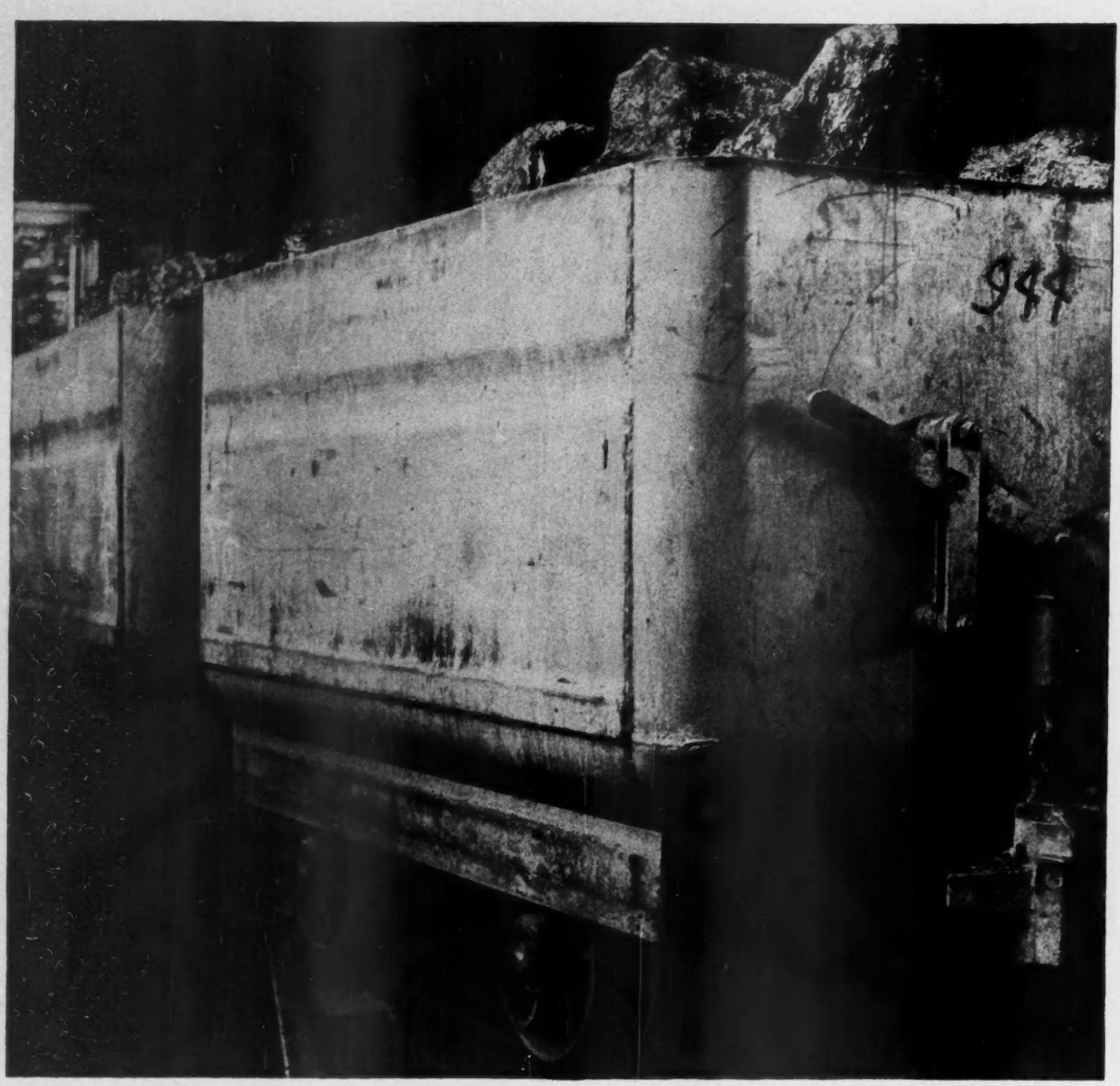

Mine cars made from SCW Cor-Ten (Photograph by courtesy of the National Coal Board)

OPERATION • MAINTENANCE • DEPRECIATION

COR-TEN CUTS THE COST

Where advantage can be taken of its high yield strength and corrosion resistance, SCW Cor-Ten can always effect a substantial cost saving.

Whatever the application (and the range continues to grow) SCW Cor-Ten is able to offer an unchallengeable combination of economy and efficiency.

COR-TEN SAVES MONEY

- Initial costs are spread over a longer service life
- Maintenance costs are reduced
- Operating costs are lowered—in transport applications payloads are bigger because of reduction in tare weight

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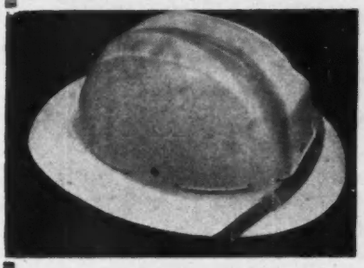

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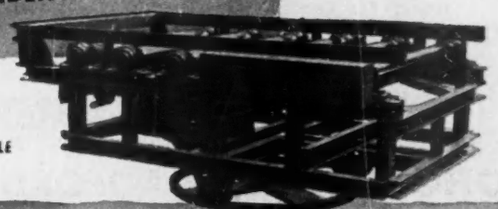

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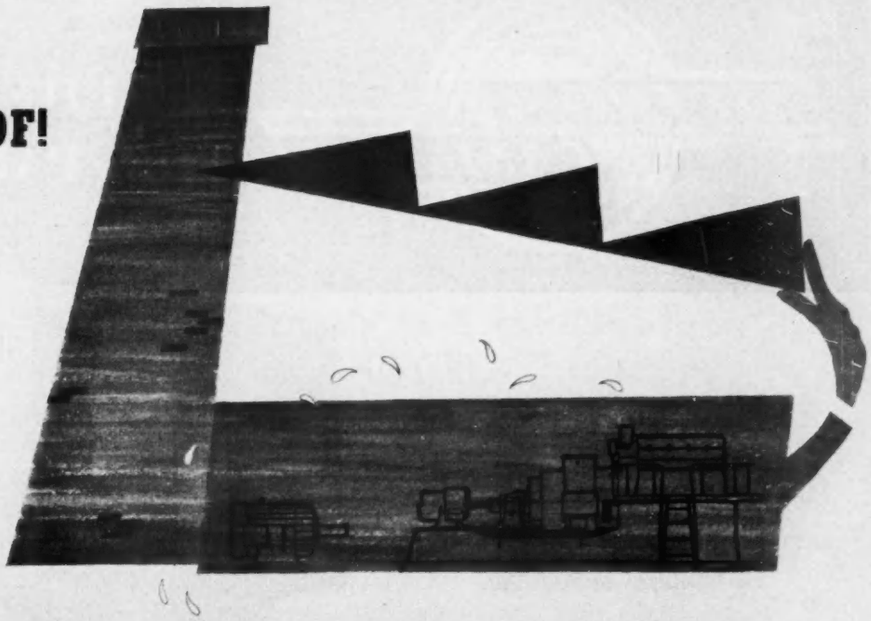

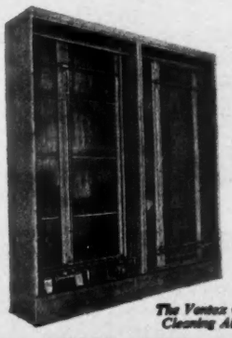

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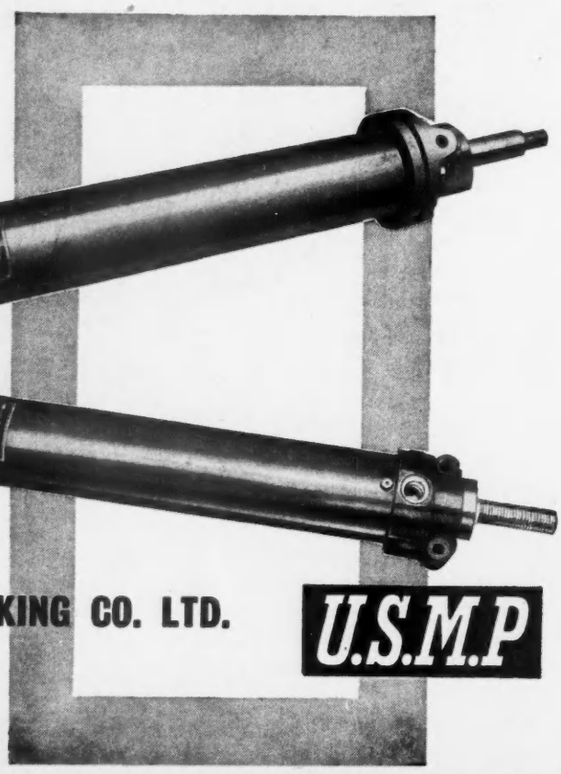

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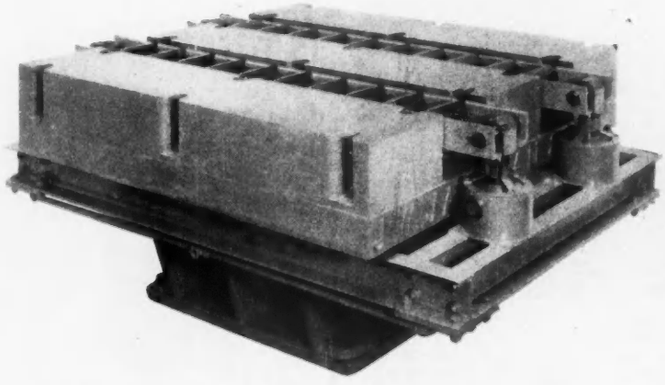

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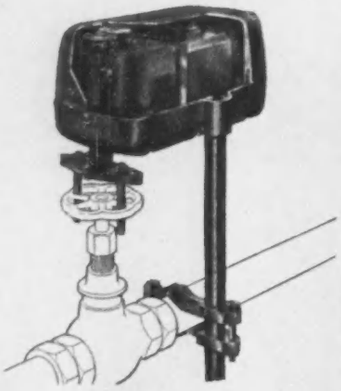

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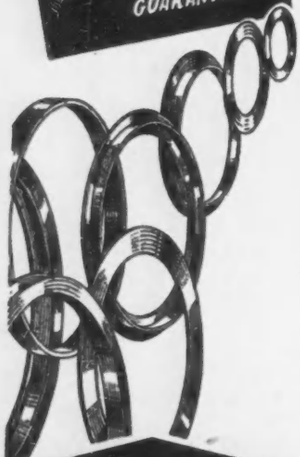

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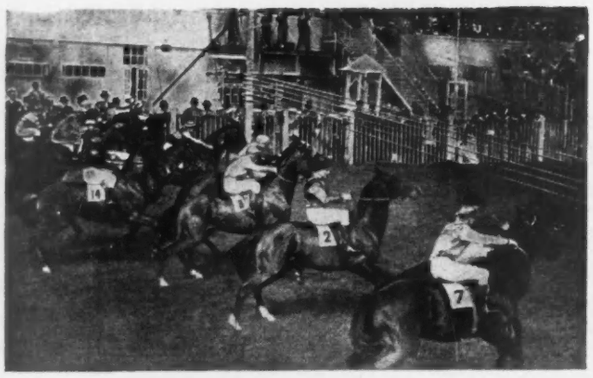

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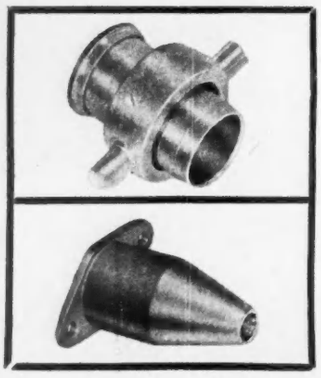

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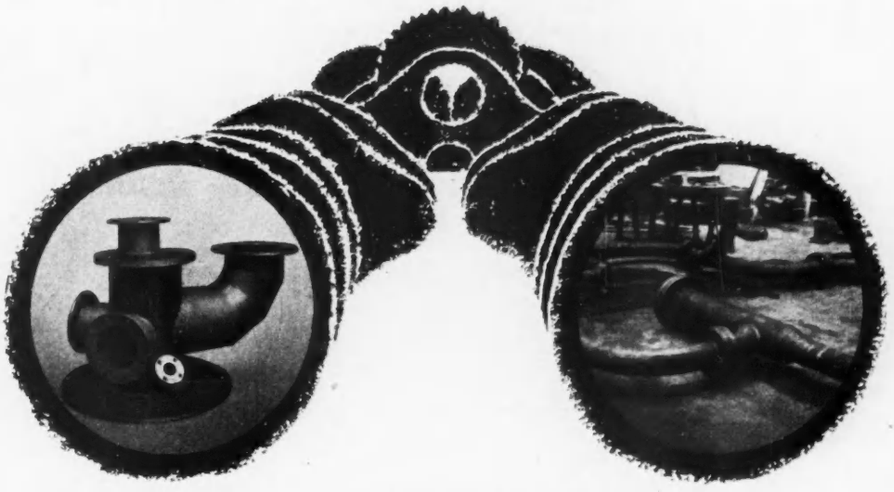

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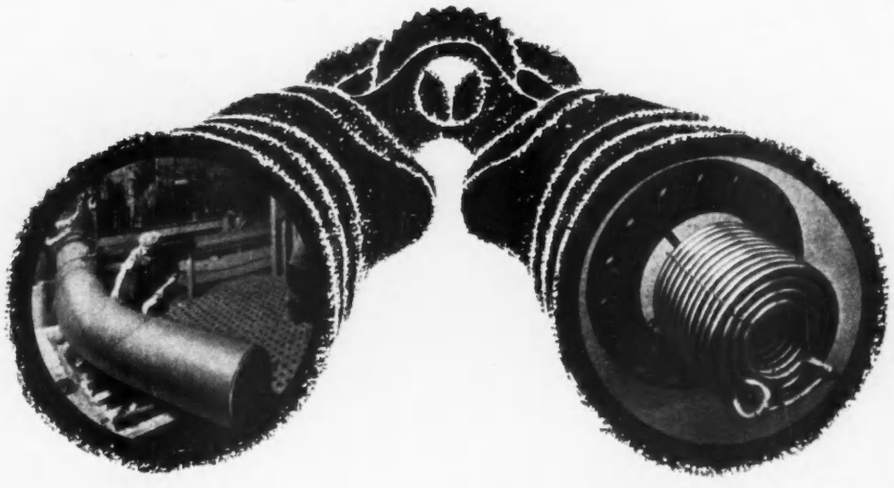

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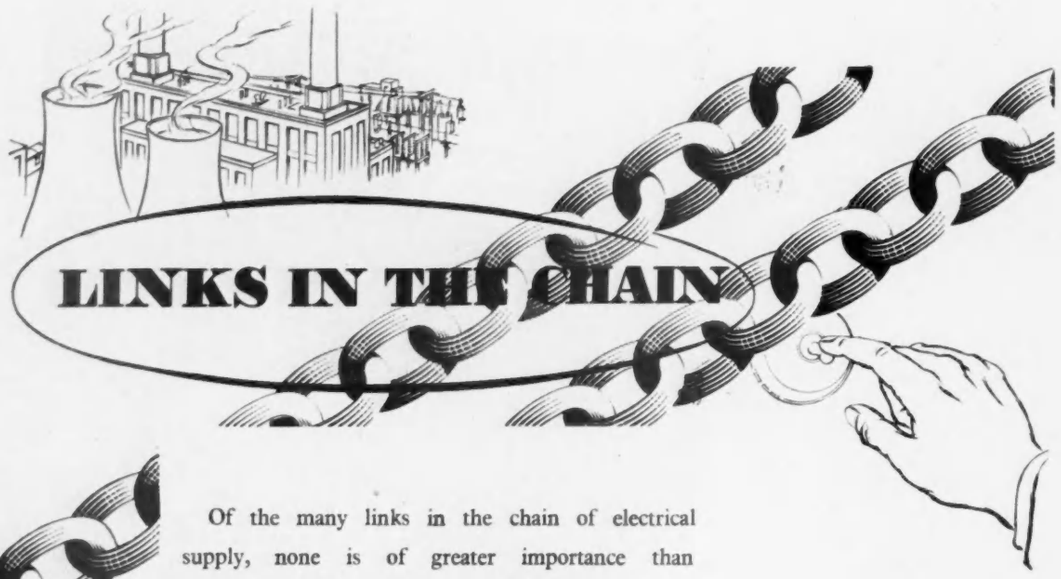
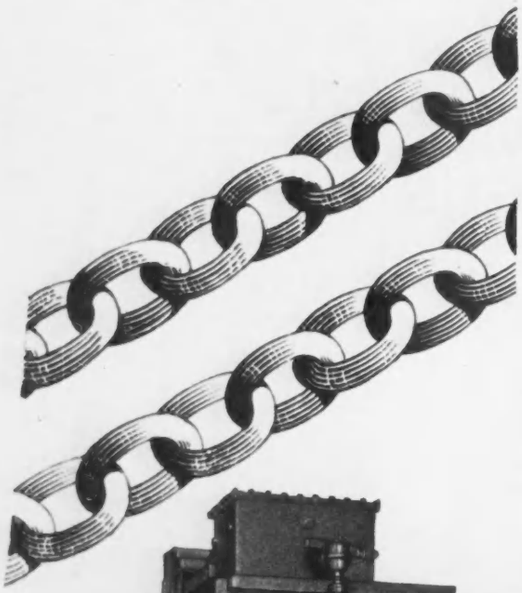


LINKS IN THE CHAIN



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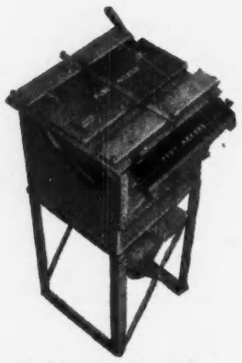
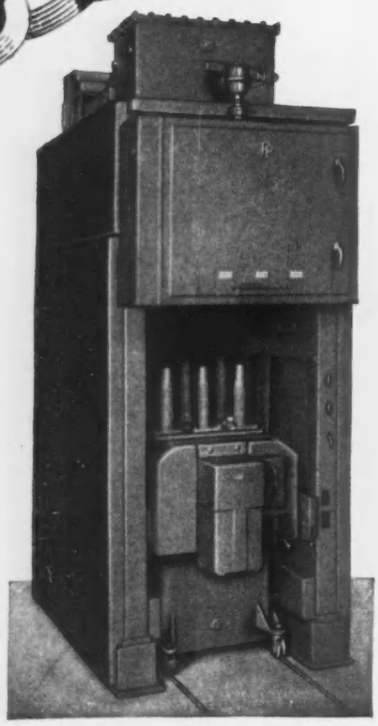


A Type OFS Fuse-switch.



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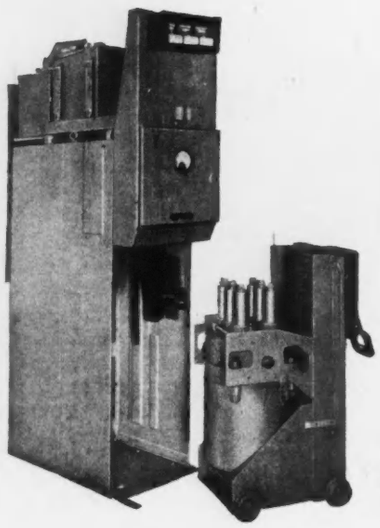

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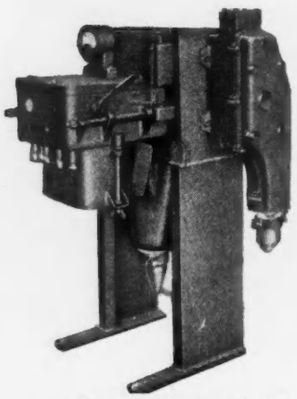

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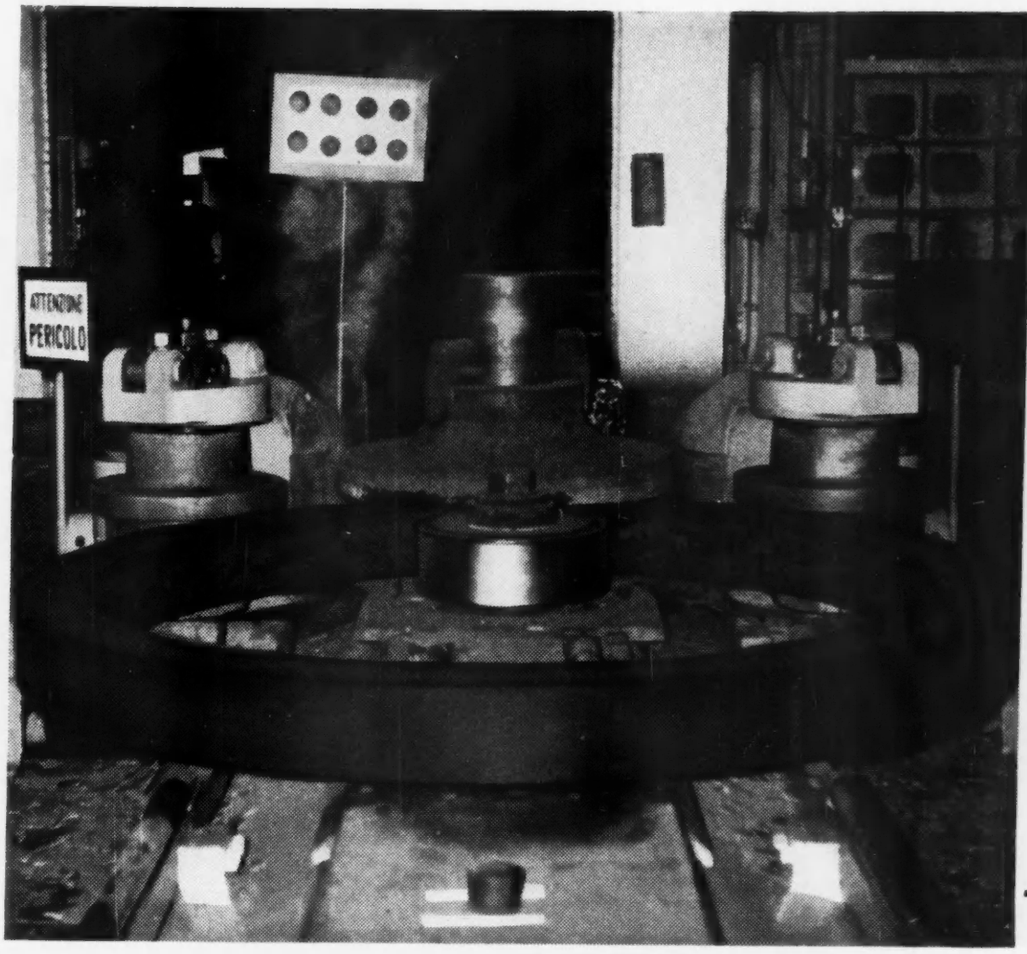

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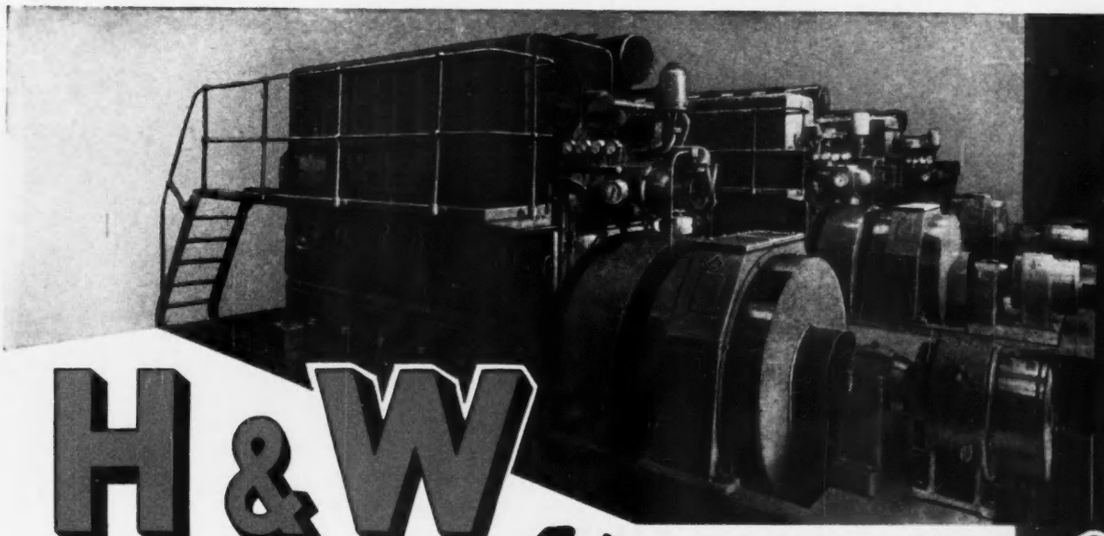

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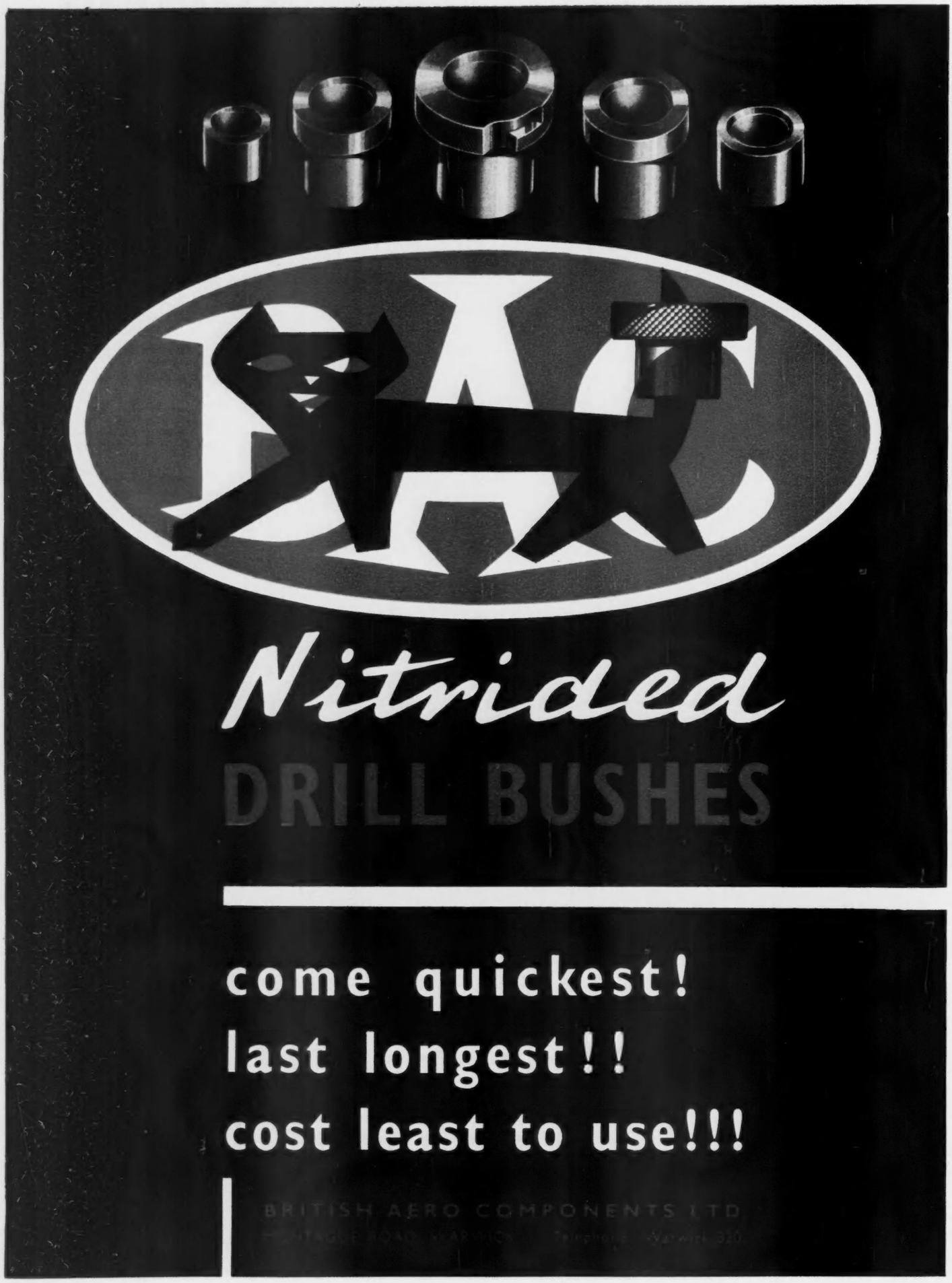
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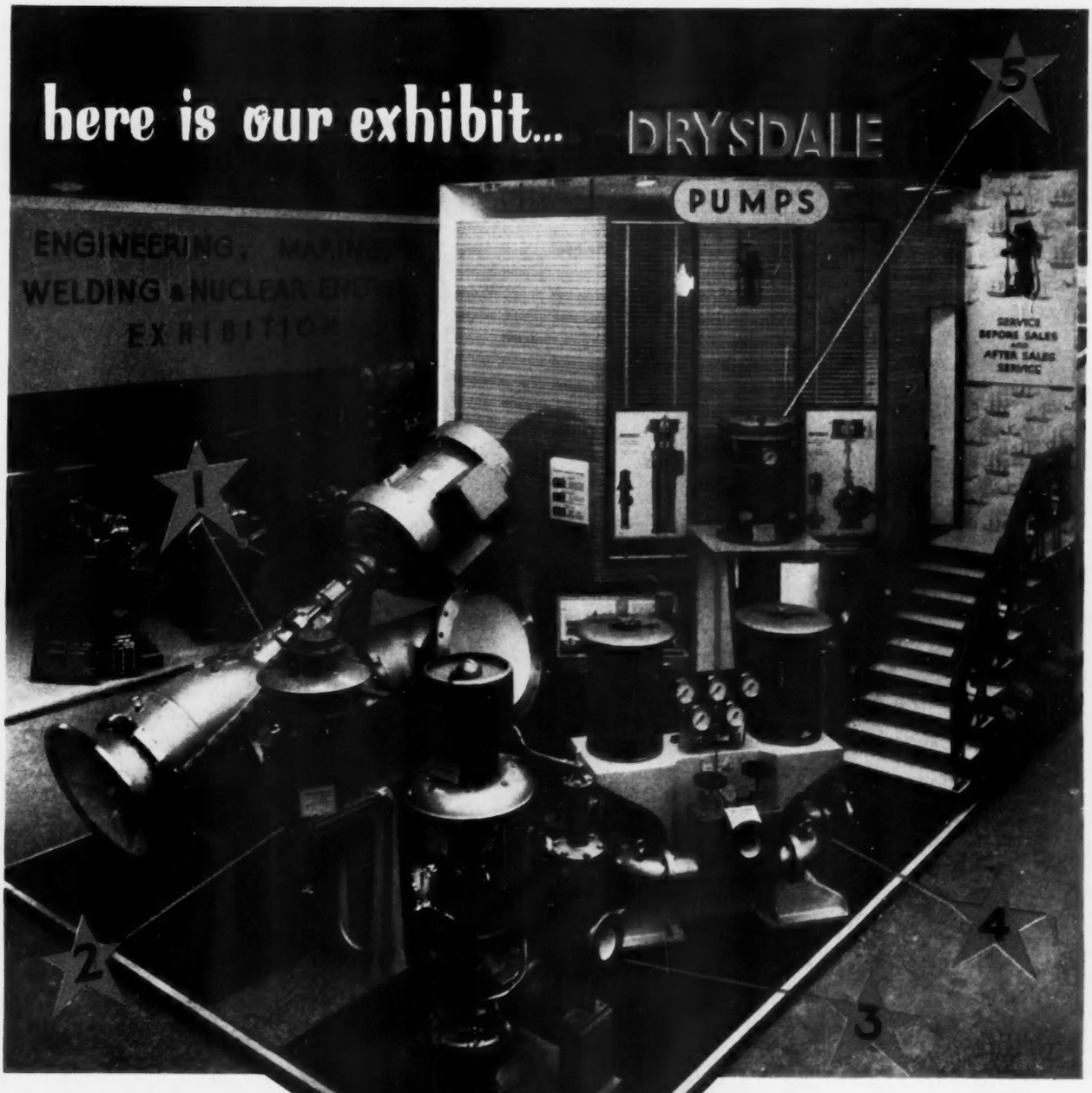

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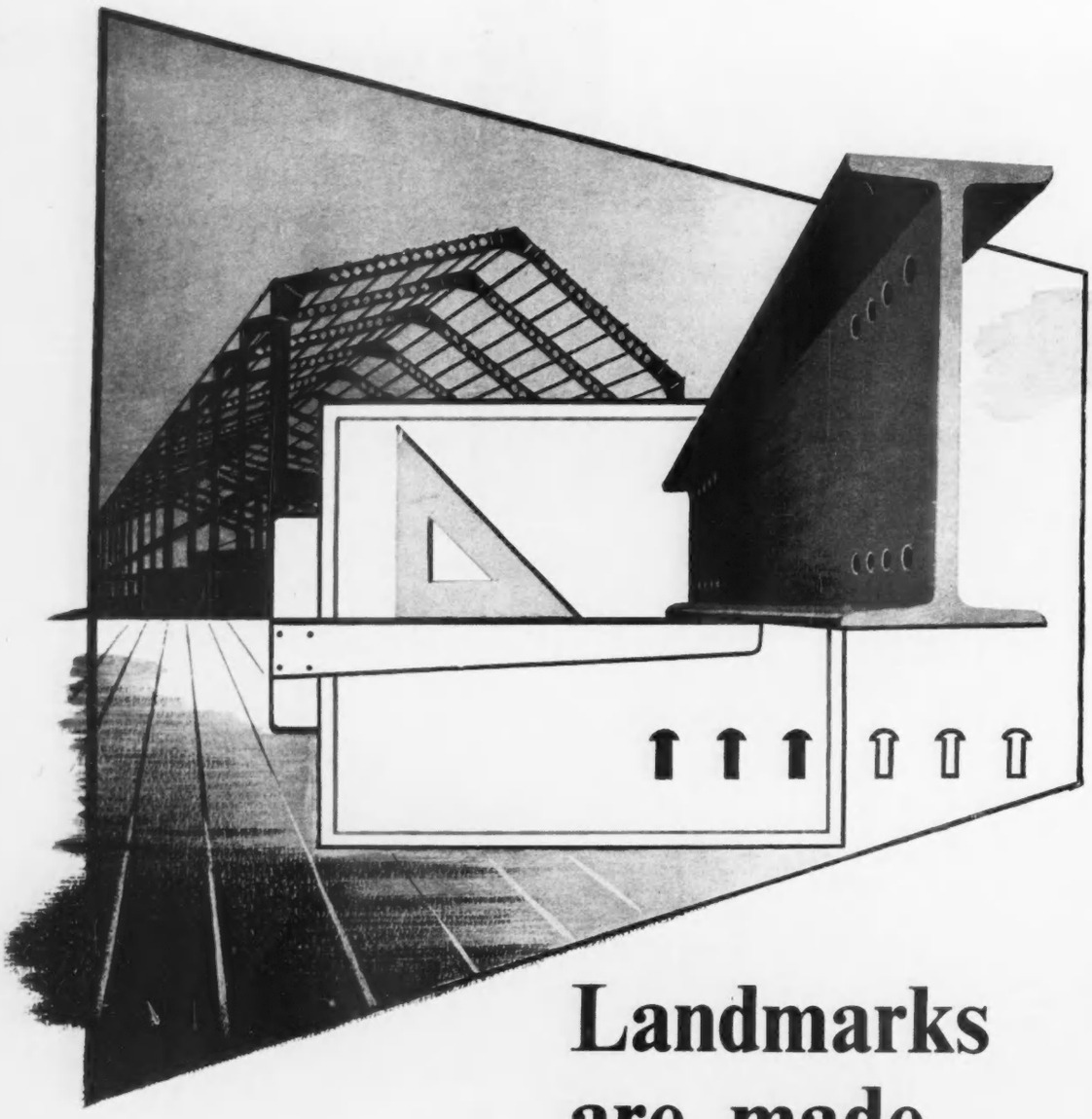

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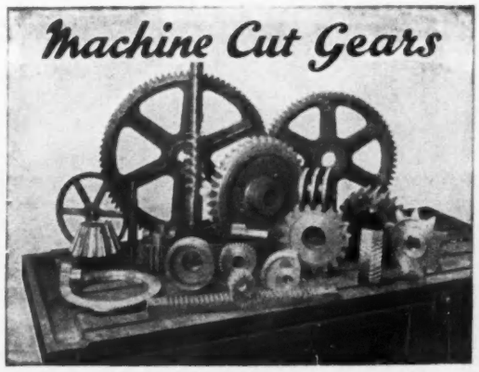

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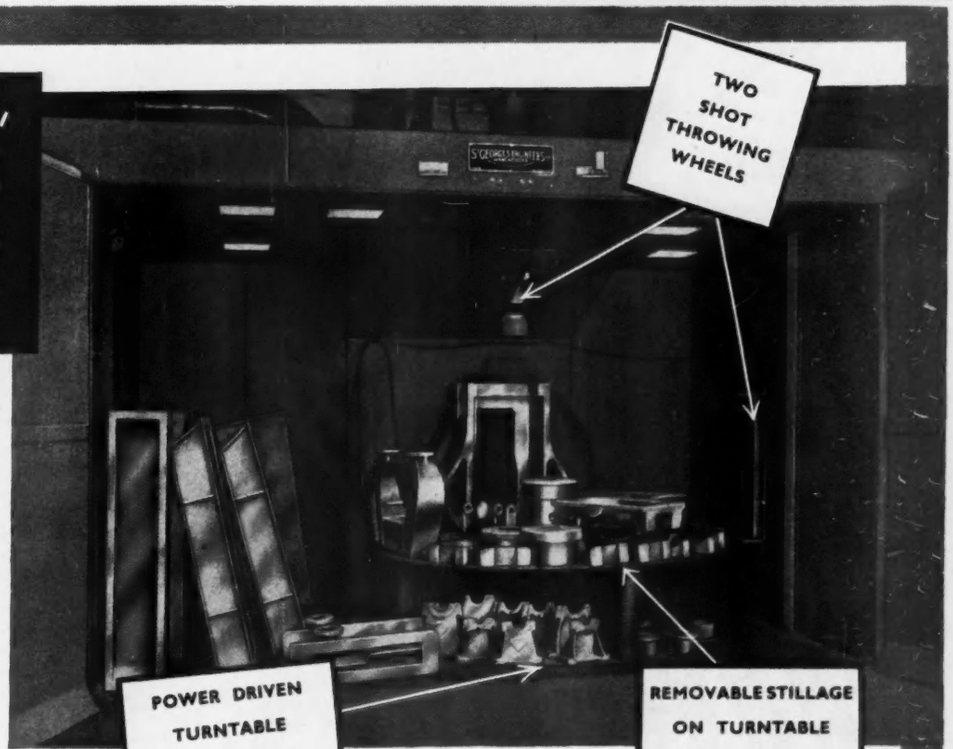

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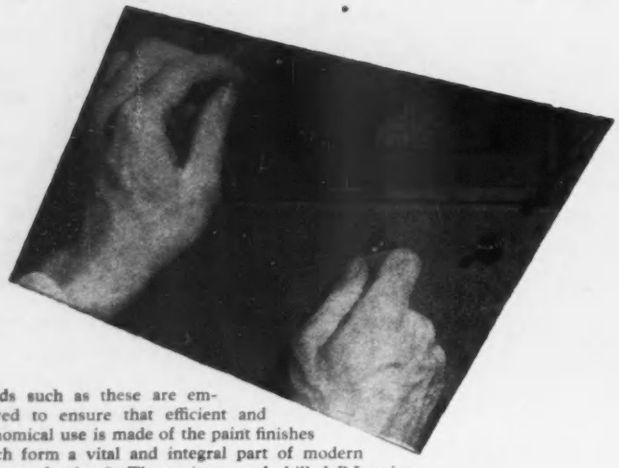

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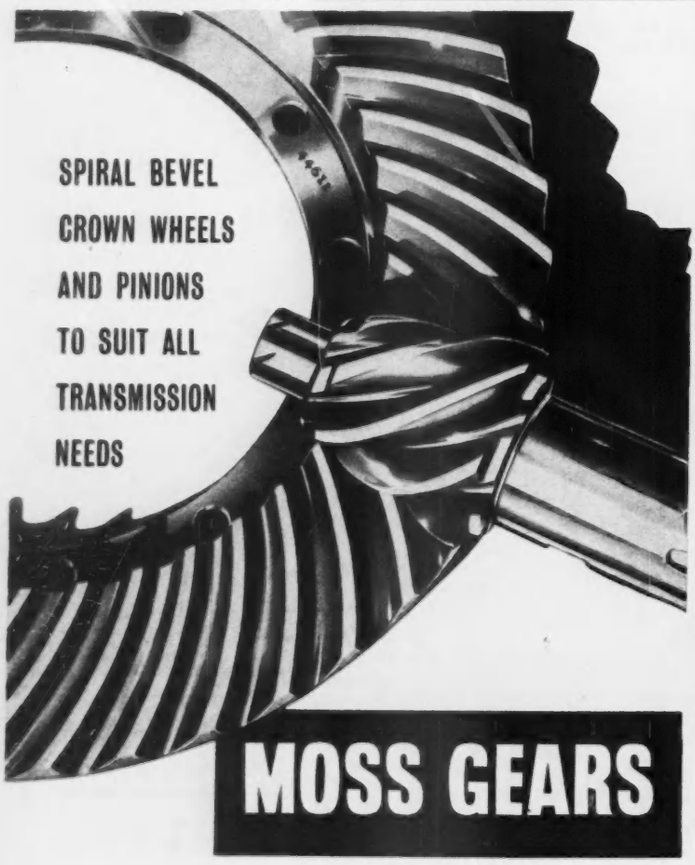

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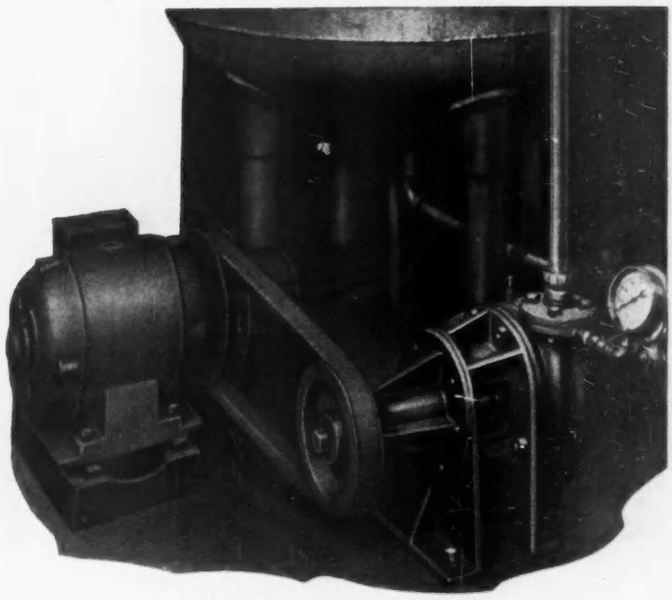

One of several stainless steel Safran 1½"/2" units, pumping Fardon's Flag Sauce at 300 G.P.M.
Photographed by courtesy of Fardon's Vinegar Company, Ltd., Birmingham 9.

SAUNDERS VALVE COMPANY LIMITED

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This Pusher Tug and a Train of eight close coupled barges was constructed by Yarrow to the order of the United Africa Company, for service on the Niger and Benue Rivers, West Africa. Overall length of the complete unit 630 feet, beam 66 feet, loaded displacement 4,650 tons.

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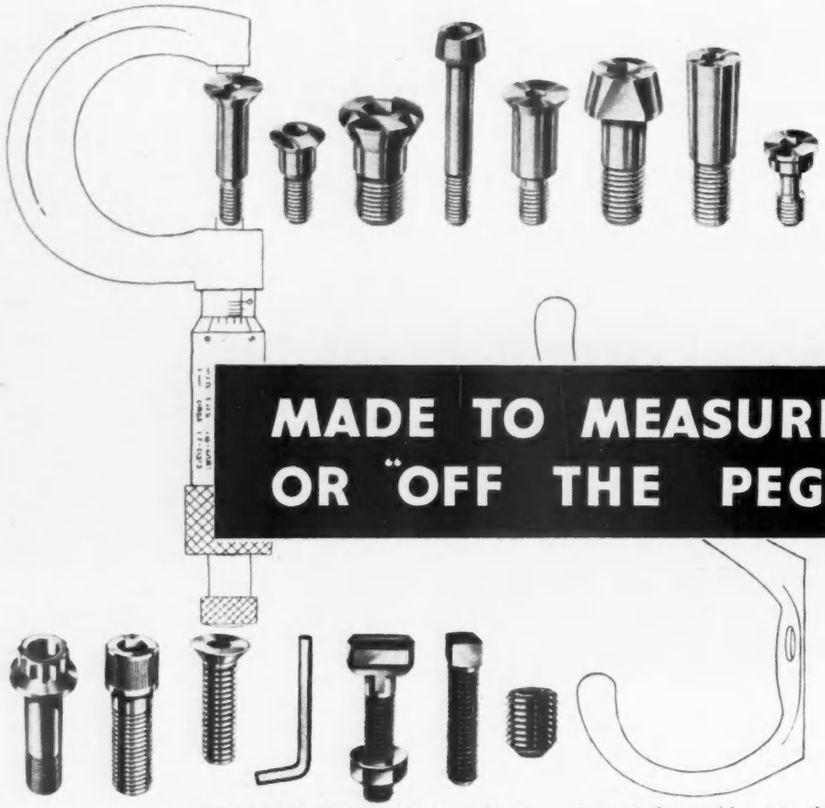

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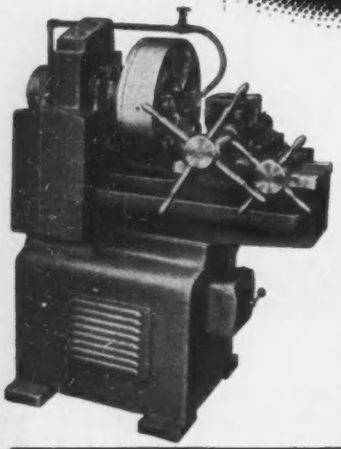

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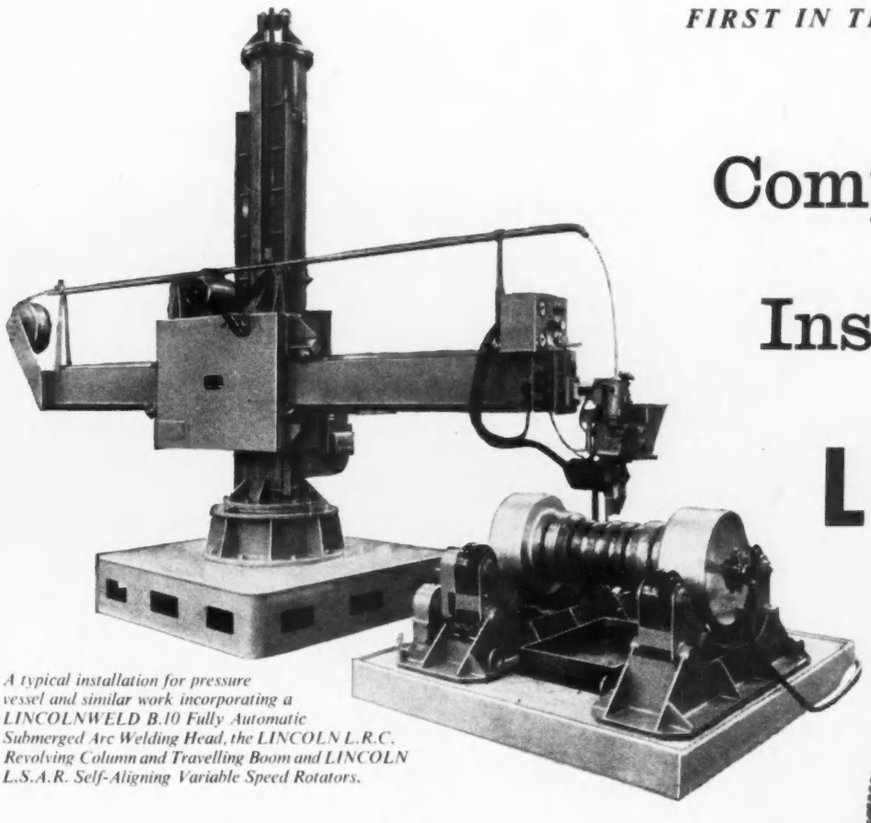

A typical installation for pressure vessel and similar work incorporating a LINCOLNWELD B.10 Fully Automatic Submerged Arc Welding Head, the LINCOLN L.R.C. Revolving Column and Travelling Boom and LINCOLN L.S.A.R. Self-Aligning Variable Speed Rotators.

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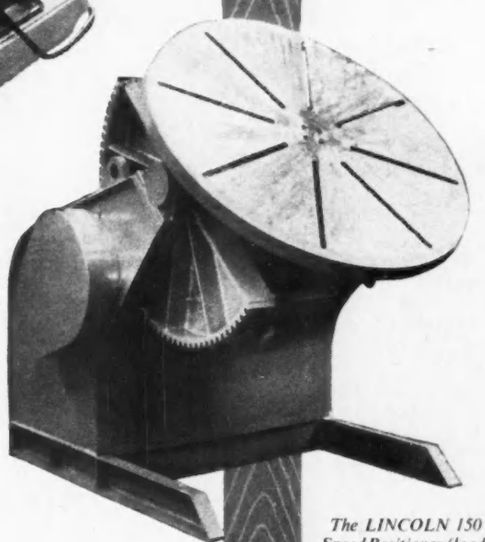

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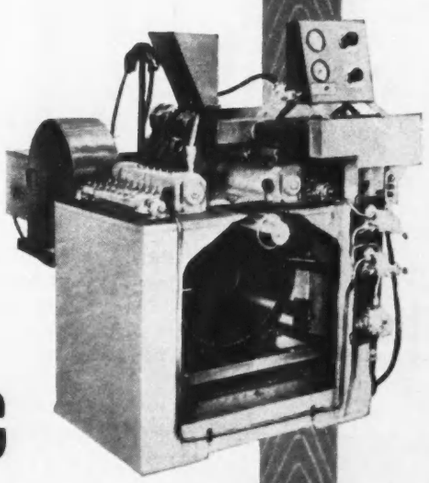

A LINCOLN Seam Welding Machine, incorporating the LINCOLNWELD M.L.3. Remote Control Automatic Submerged Arc Welding Unit.

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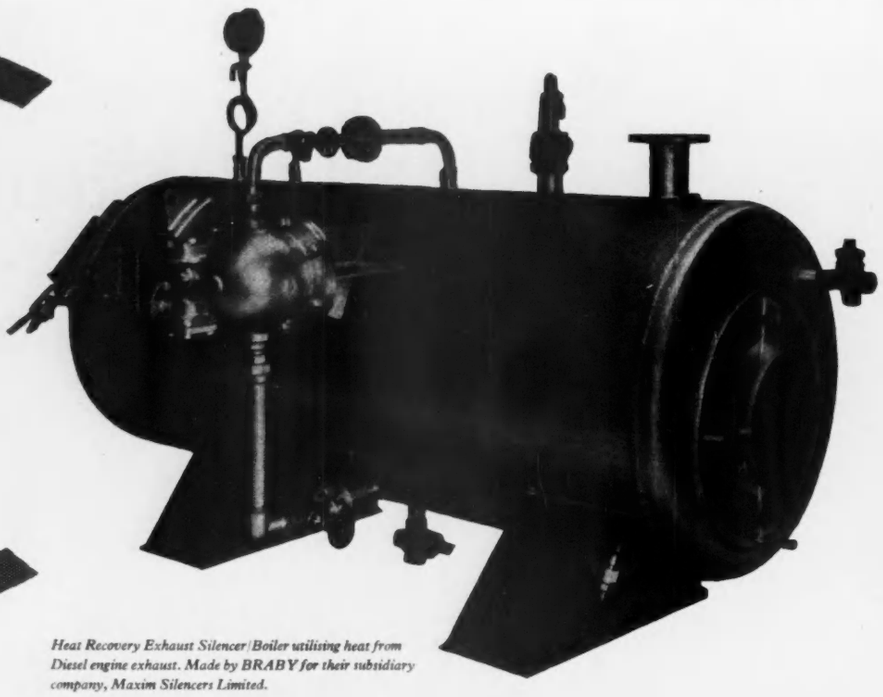
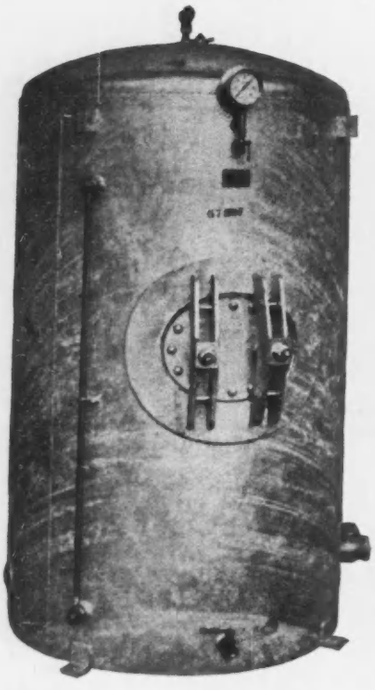
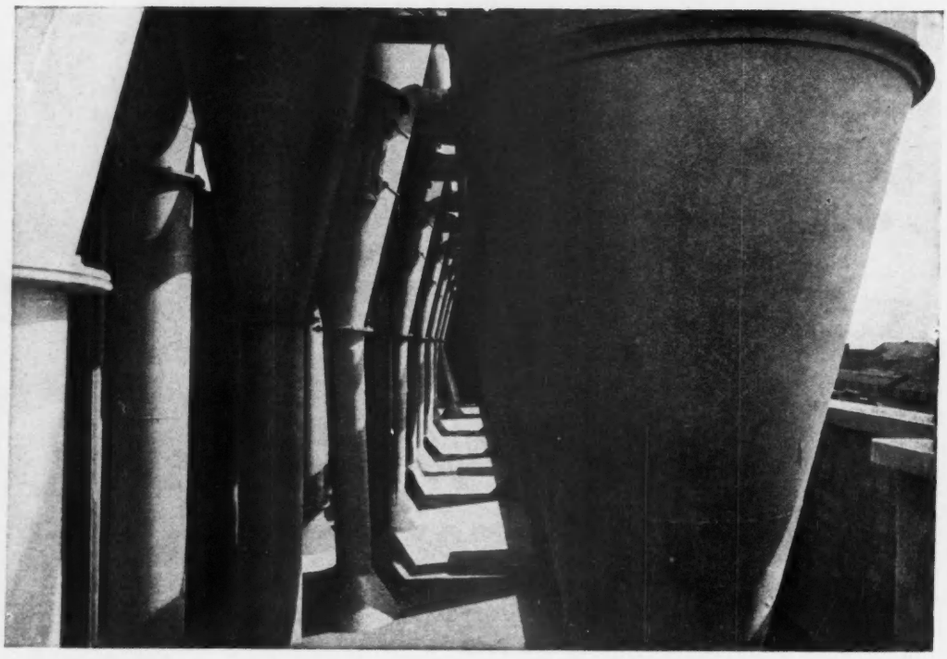


Heat Recovery Exhaust Silencer/Boiler utilising heat from Diesel engine exhaust. Made by BRABY for their subsidiary company, Maxim Silencers Limited.



Pressure Cylinder supplied to Mono Pumps Limited.



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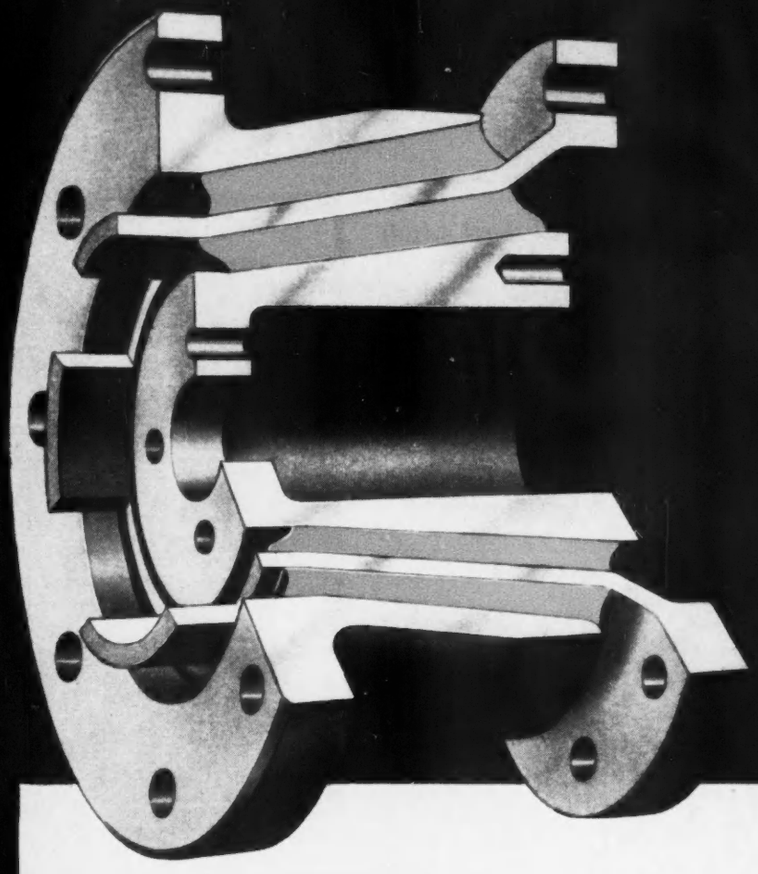

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Damp Torsional Vibration, Resist Thrust, Absorb Shock Loads

A high degree of torsional flexibility combined with large torque capacity singles out the Double-Cone Coupling for drives in which torque fluctuations and torsional vibration must be controlled.

The design is suitable for torques up to 100,000 lb. ins. and torsional deflections from 5°-10°. It permits some angular misalignment and is designed to resist end thrust.

Available in a number of standard sizes, the Double-Cone Coupling is of robust construction and requires no maintenance.

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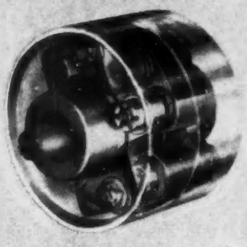

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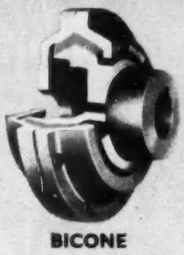

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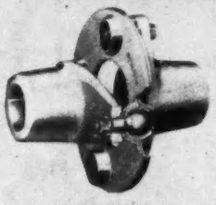

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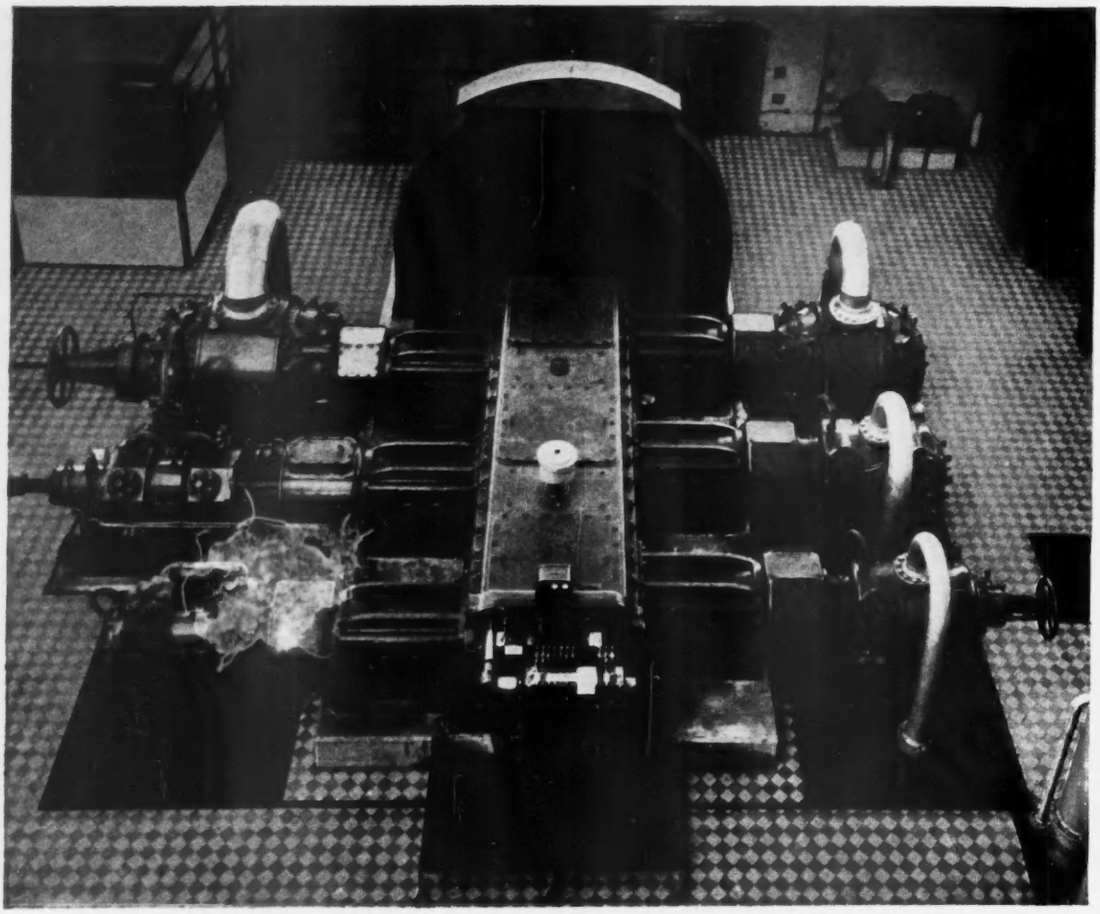

Highly satisfactory—that's the performance record of CLARK CBA-6 compressor in AMMONIA SYNTHESIS application at Lille, France.

At Etablissements Kuhlmann's La Madeleine Plant at Lille, this Clark compressor has given dependable service since 1952. A 17" stroke motor-driven machine, it is rated at 2250 bhp, with discharge pressure to 4840 psia and suction pressure to 1690 psia.

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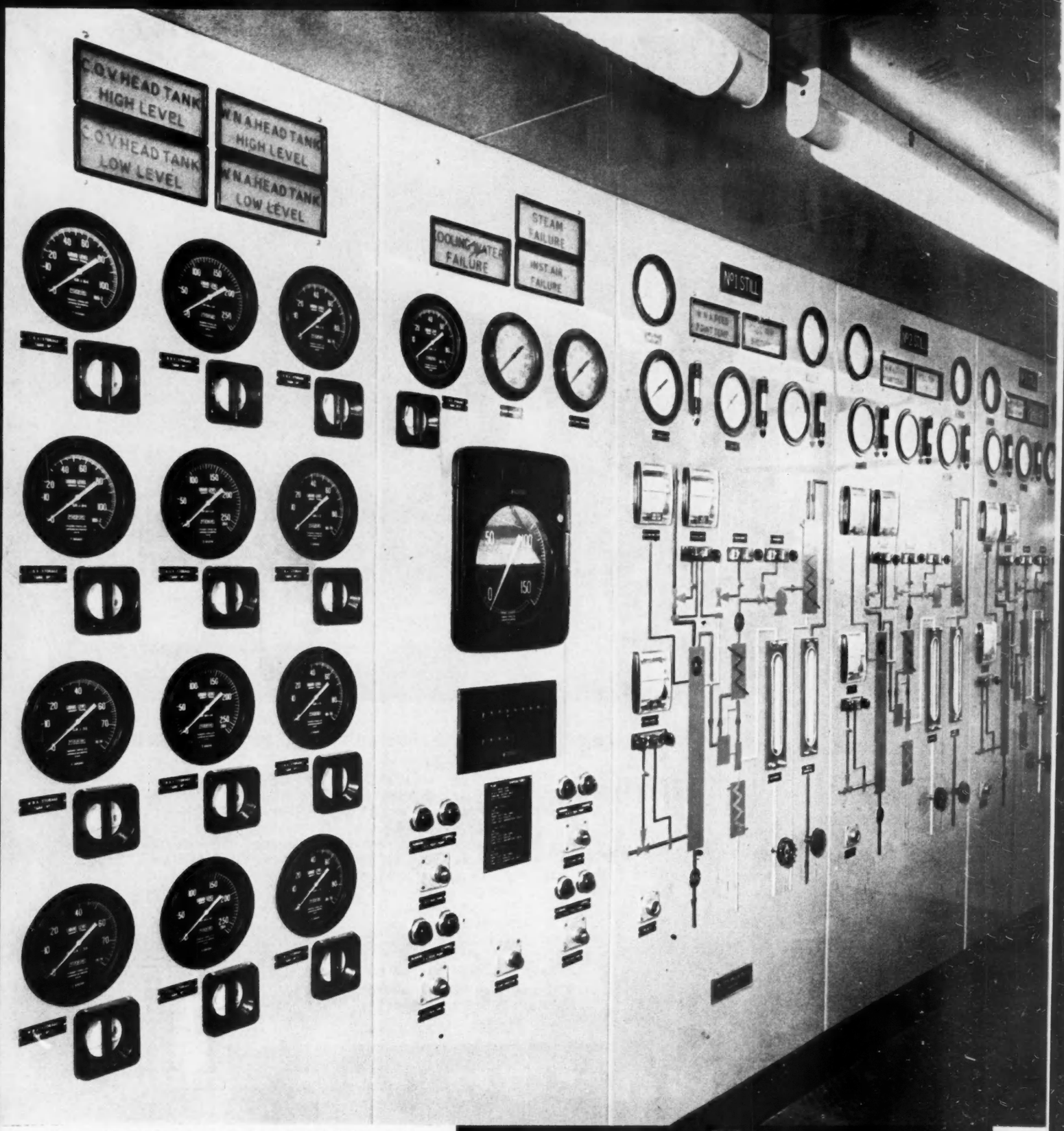

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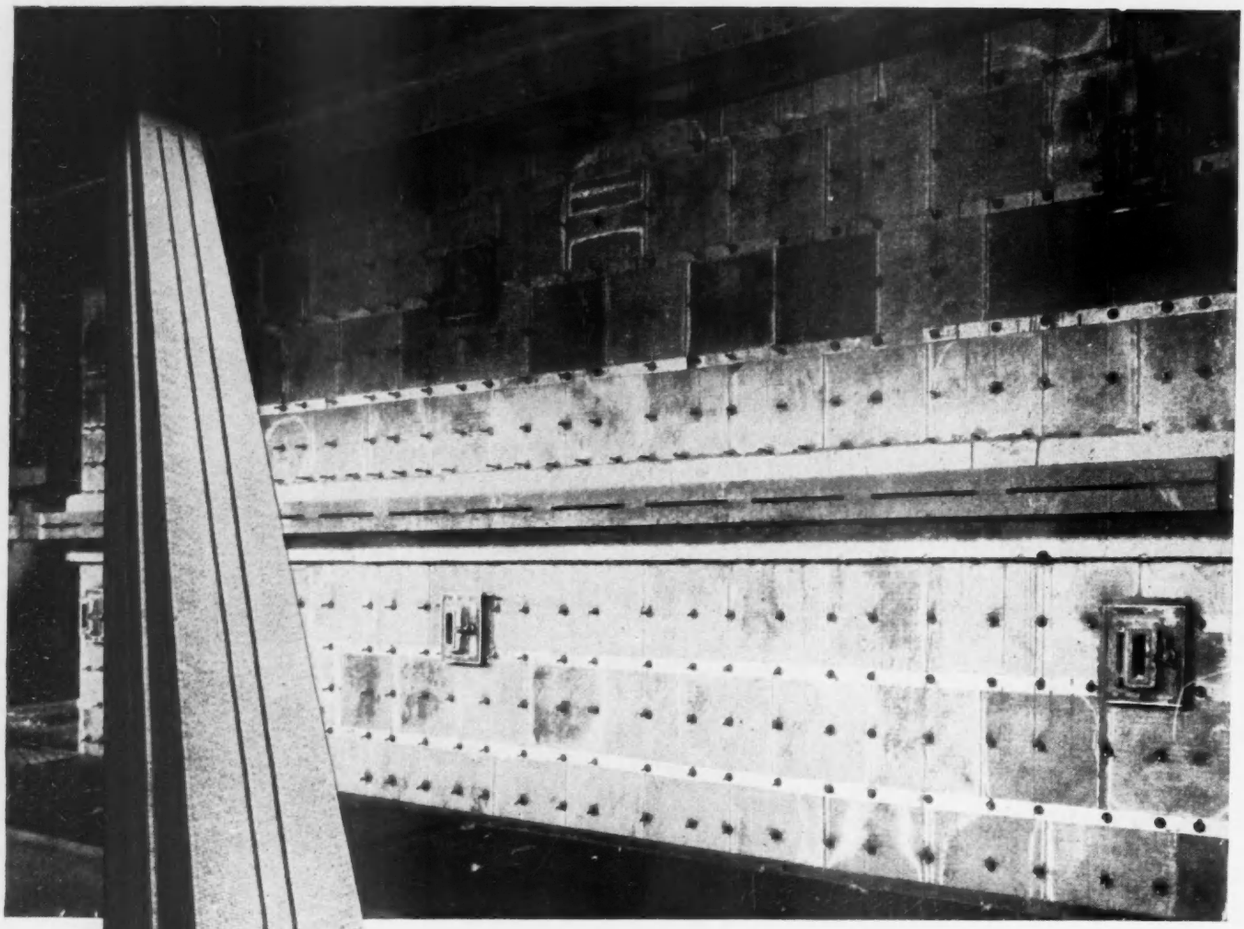

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R. B. HILTON LTD, while fully maintaining their interest in well tried and traditional methods, are actively to the fore in developing new systems to suit special conditions and demands.

The illustration shows the refractory cladding applied to a very large power station boiler. In this instance prefabrication was extensively used, and the photograph shows the installation ready to receive the low temperature insulation. This particular system, developed and patented by the R.B.H. GROUP, is now used very widely on modern power station boilers.

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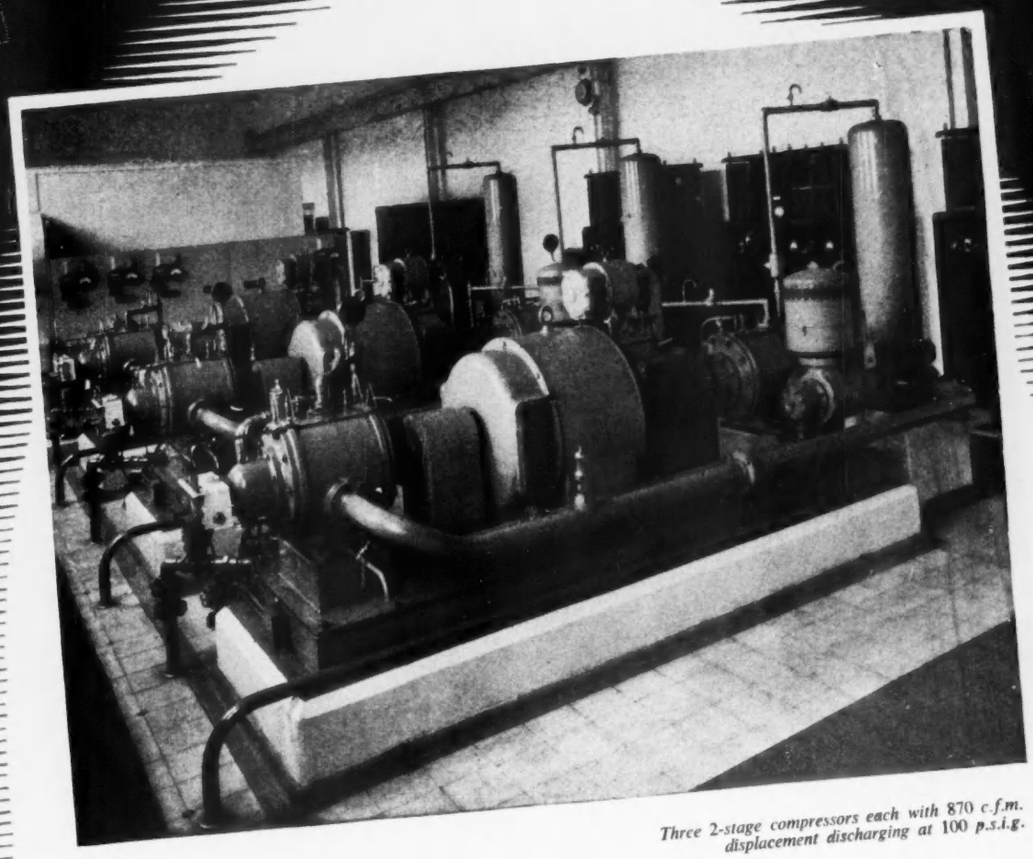

Three 2-stage compressors each with 870 c.f.m. displacement discharging at 100 p.s.i.g.

Rotary Compressors and Vacuum Pumps

The Hick Hargreaves Rotary Compressor is of the eccentric rotor type, with sliding steel blades which are prevented from making contact with the cylinder walls by restraining rings. High rotational speeds can thus be achieved without great frictional losses. Hick Hargreaves Rotary Compressors have many other advantages — easy and cheap installation; retention of initial high performance; regular air flow and low noise level; easy maintenance due to the absence of moving valves, and the reduction of wear to a minimum by the use of roller bearings.

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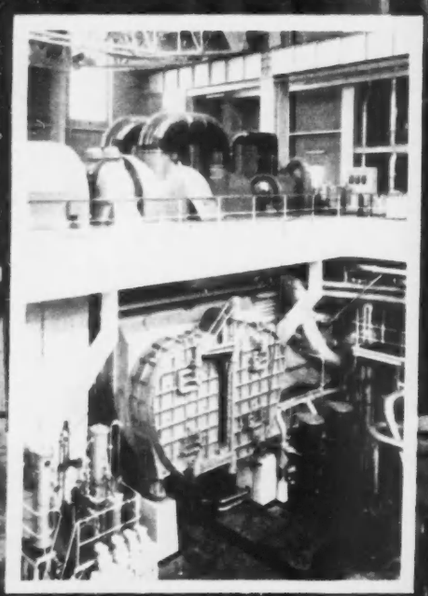
✳ Power in the making



One of three PARSONS 60 MW turbo-generators and condensing plant at C.E.G.B. Tilbury Power Station.

✳ To obtain high overall thermal efficiency of a steam power plant a well designed and good performance condenser is necessary. Such large units are produced in considerable numbers at Parsons Heaton Works. A completed condenser with a cooling surface of 46,000 square feet is seen in the Condenser Shop ready to be dismantled and sent to site.

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TRANSFORMERS
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PARSONS

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Hundreds of cutting teeth...

remove the toughest deposit on any tube cleaning job!

In each swinging arm the long cutting surface of several cutters working together, comprising hundreds of sharp teeth ensure removal of the toughest deposits in straight or curved tubes.

Note, in the diagram, the wide swing of the arms of the Lagonda swing-frame head—wider than in any other swing-frame head—giving plenty of latitude for any possible variation in the I.D. of the tube.

Of course a head like this takes a lot of drive to get the best out of it. This is where the powerful Lagonda motors come in, with double ball thrust bearings and full lubrication that let practically all the power through to the cutter head. The full range of Lagonda tube cleaners caters for all types of deposits in tubes straight or curved, from $\frac{1}{2}$" dia. upwards. Write for catalogue Y-42.

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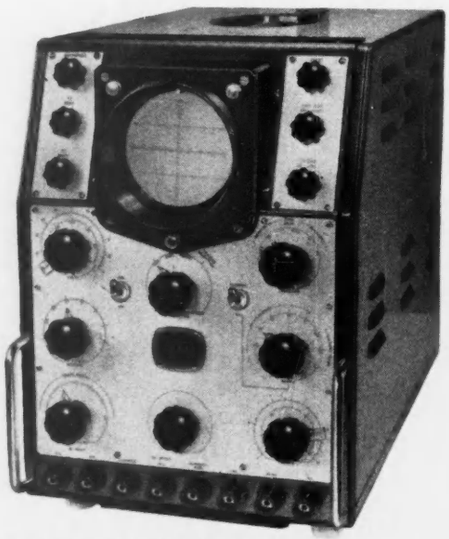
within the range of 0-200 c.p.s.



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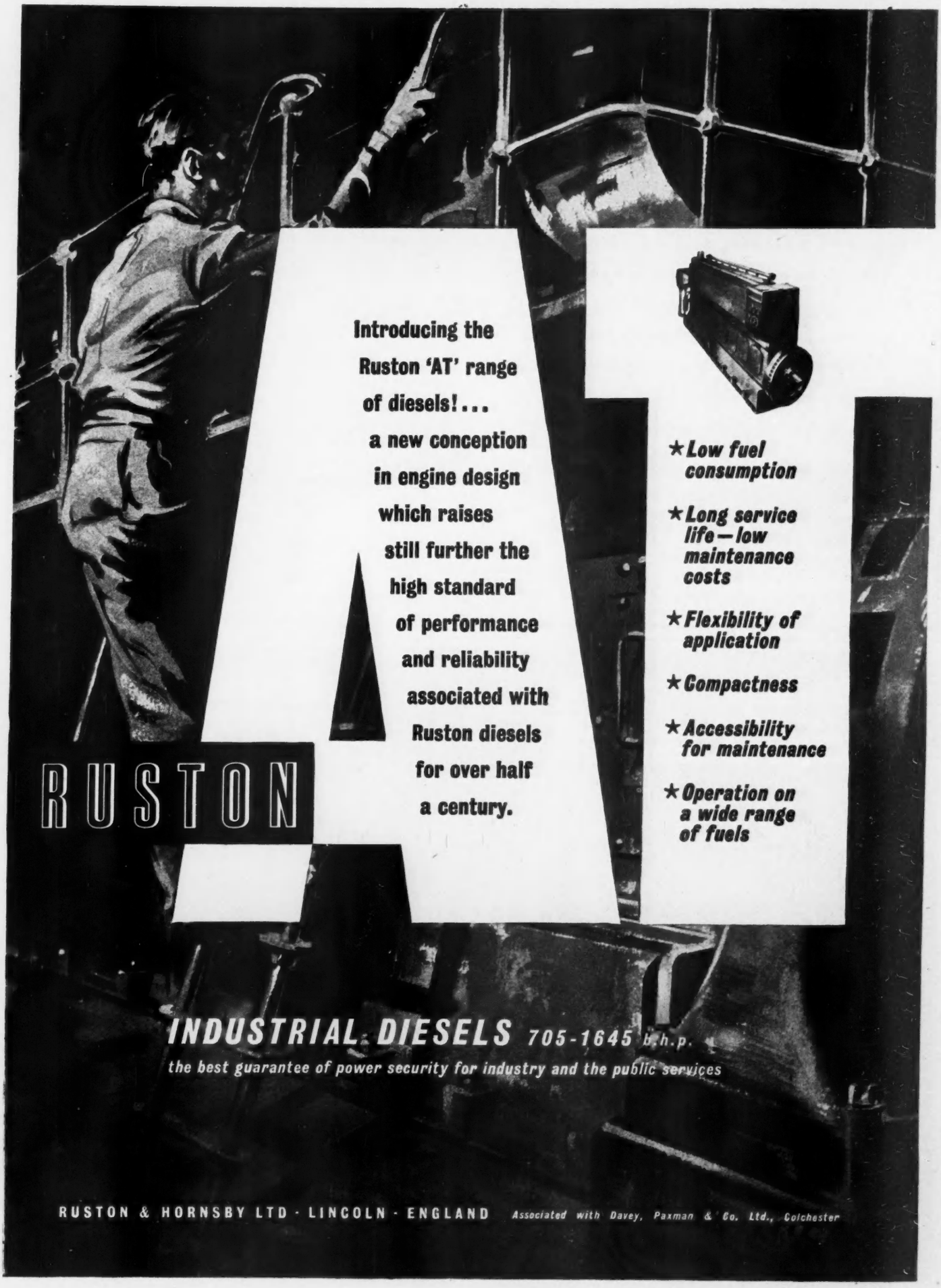
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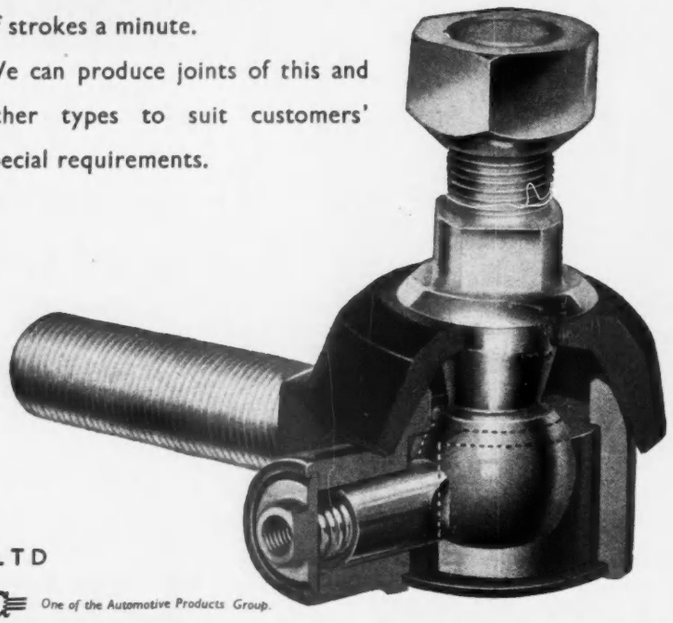

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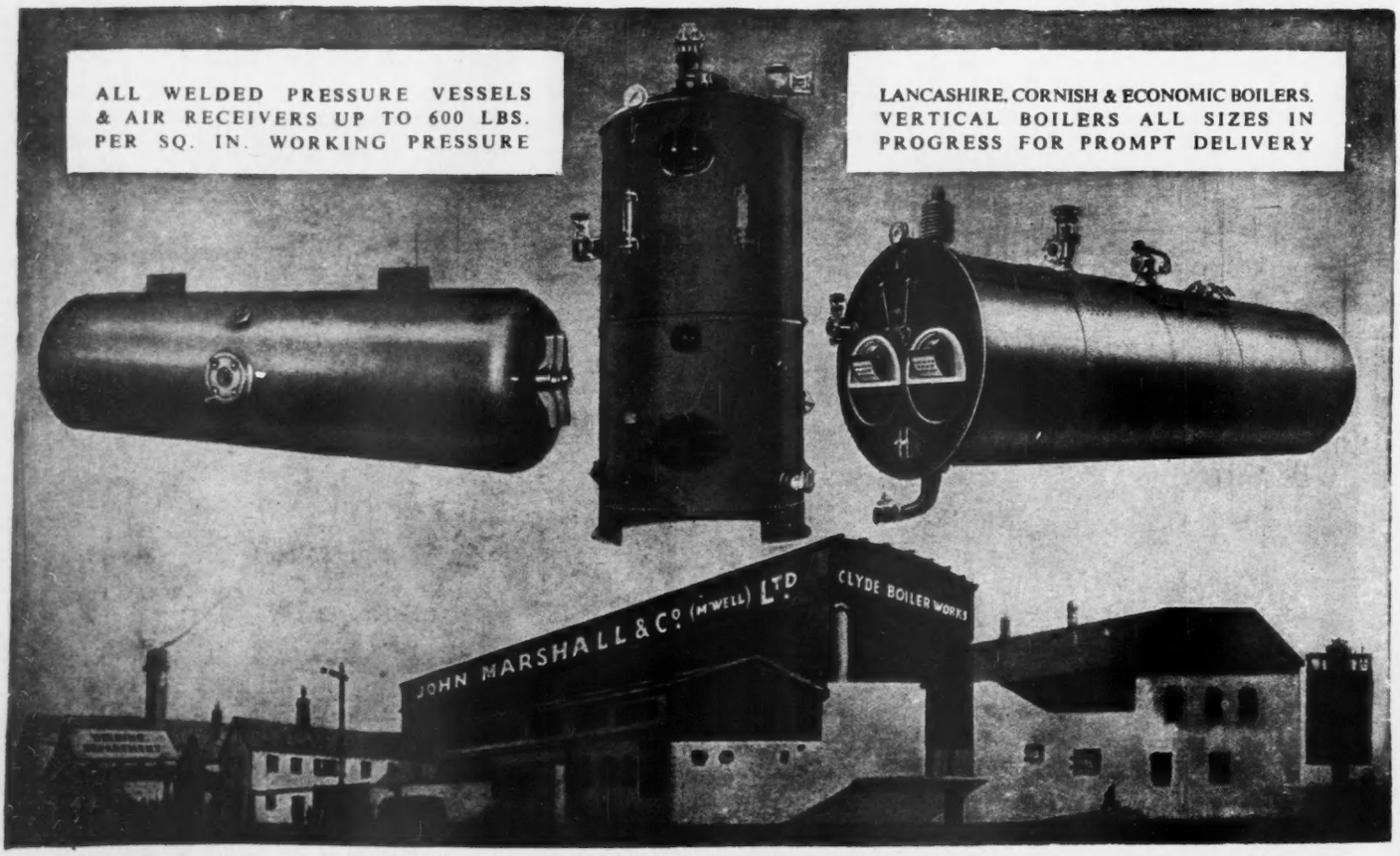

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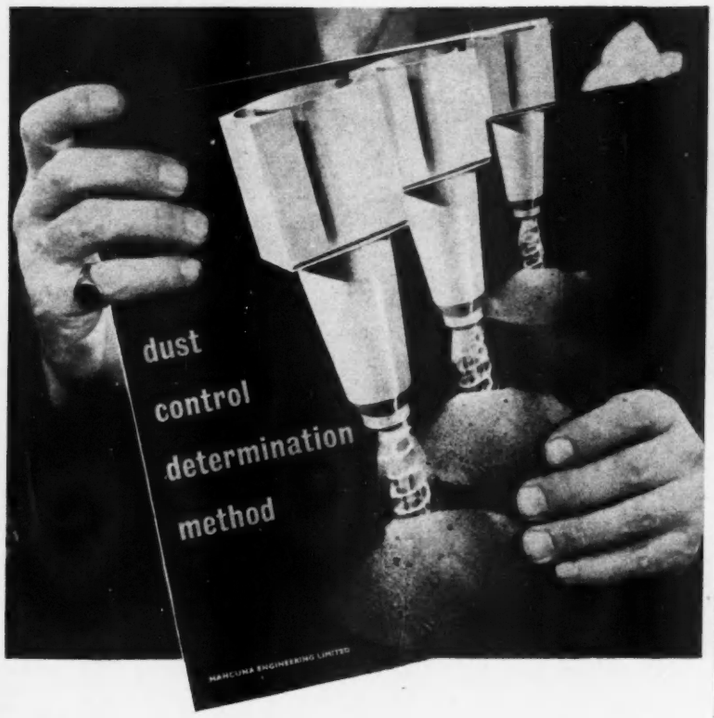

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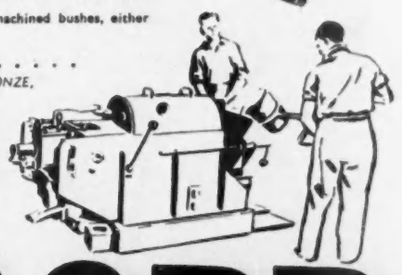

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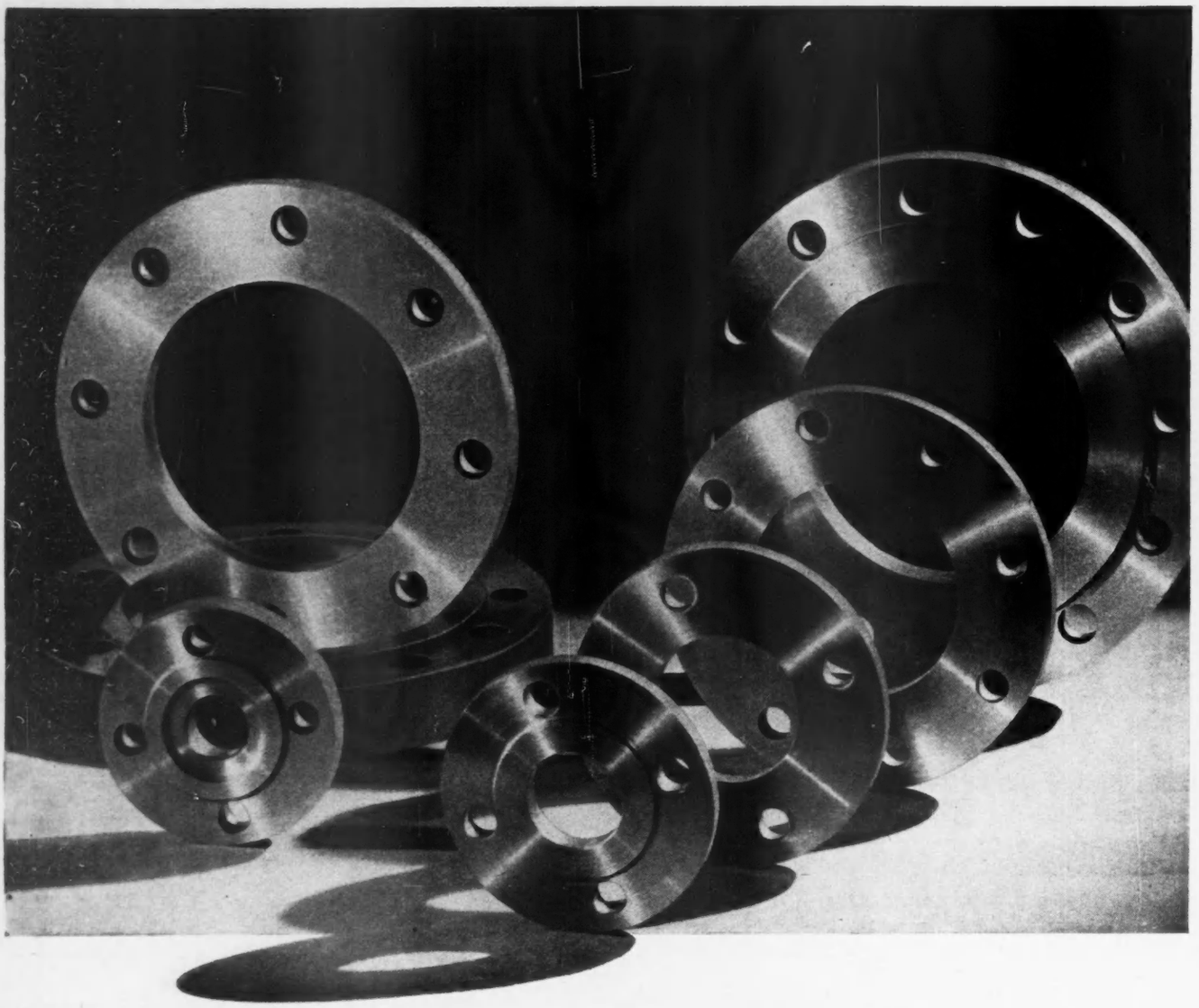

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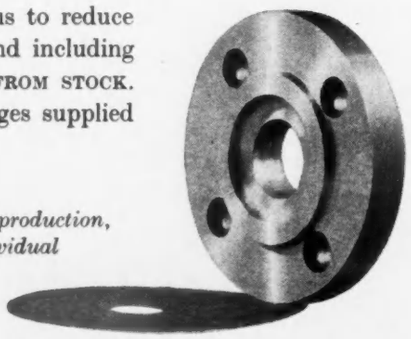

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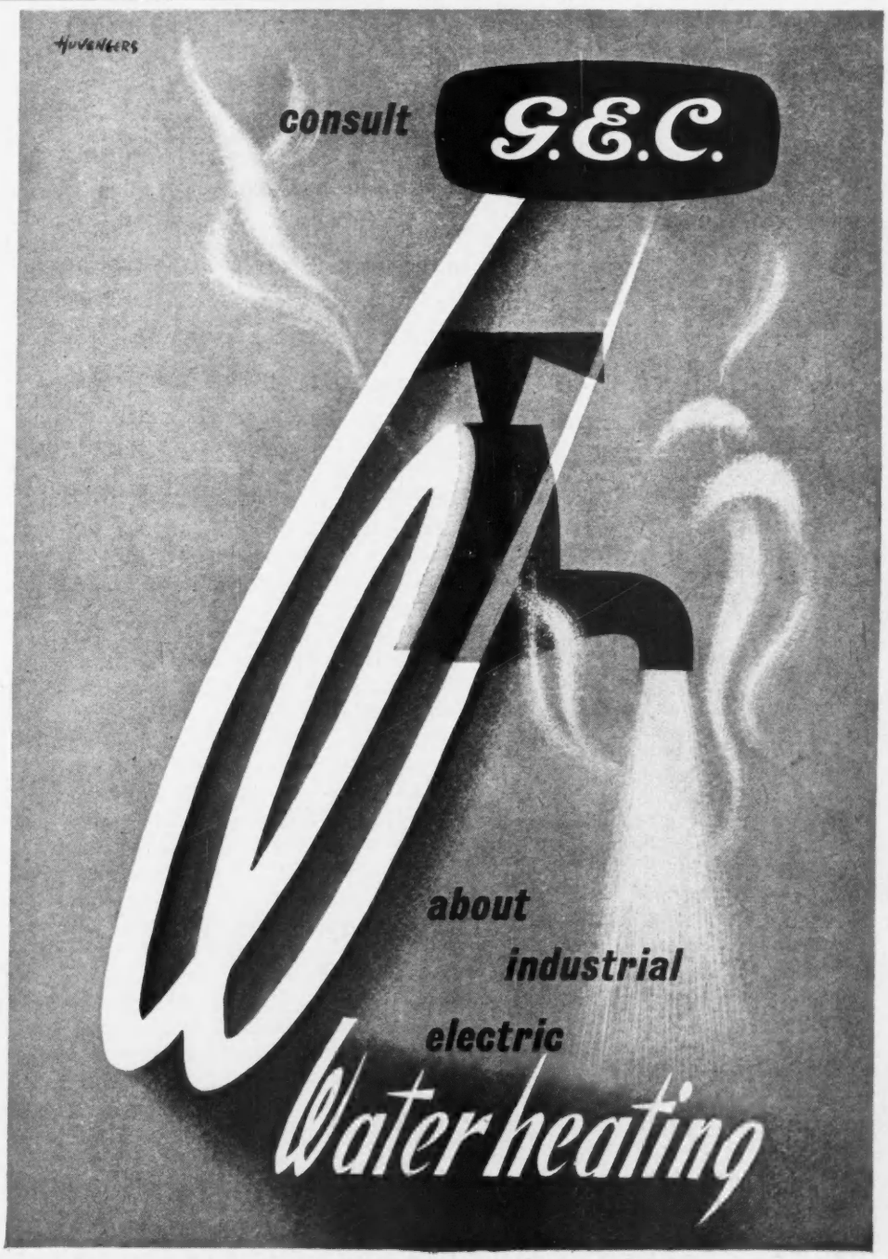

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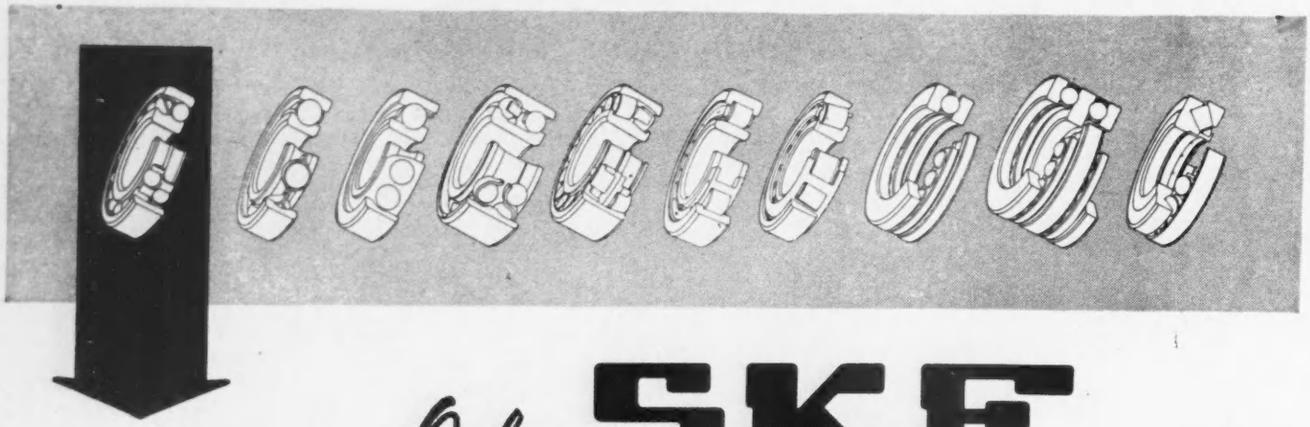

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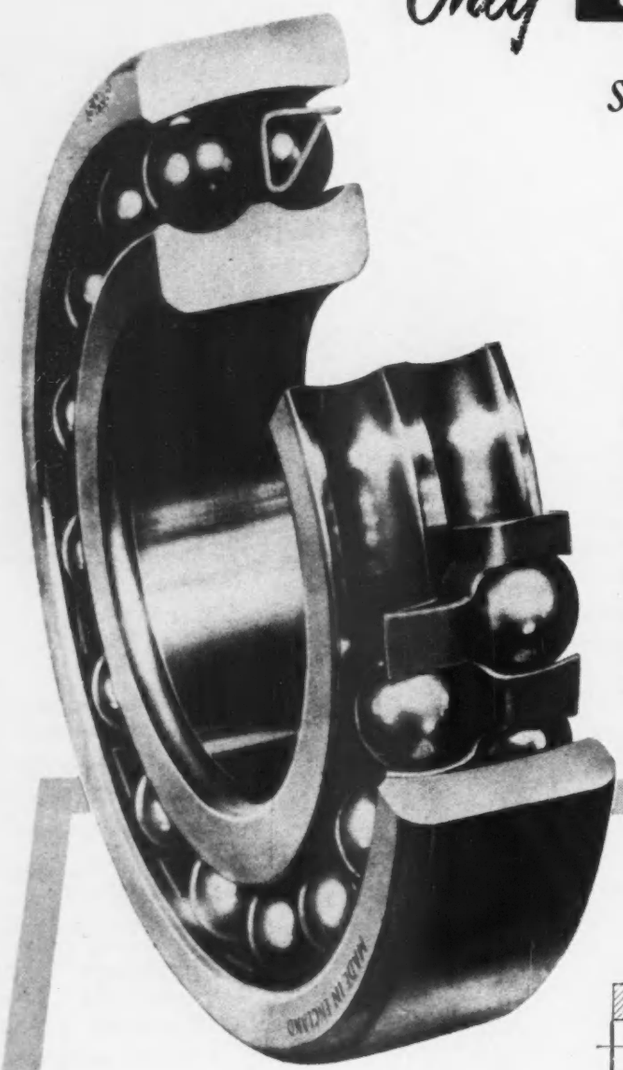

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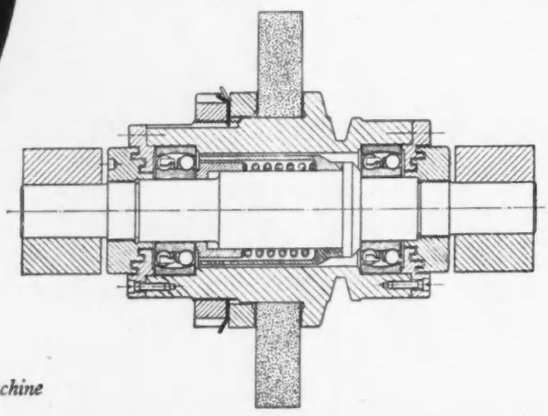

Bearing scheme for grinding wheel of leather shaving machine

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THE ENGINEER

No. 5392 MAY 29, 1959 VOL. 207

RE-ORGANISATION OF RESEARCH

The Annual Report of the National Physical Laboratory was published last week. It bears witness to the effect upon that establishment of the energetic new thinking about the functions of the Department of Scientific and Industrial Research which has followed upon the recent placing of its destinies under an executive Council. We referred to that new thinking in a leading article in our issue of May 15, entitled "New Brooms in D.S.I.R." The work of the N.P.L. is being re-organised in several respects. In particular the old Electricity, Metrology and Physics Divisions have already disappeared. In their places, reflecting in their titles the special interest of the laboratory in the more fundamental aspects of technology, there have appeared the Applied Physics, Basic Physics and Standards Divisions. It is implicit in the wording of the report that the value of the work done at the N.P.L. in relation to what is done elsewhere, is being questioned ; and it is clearly being asked by the executive Council whether it would not be appropriate to pass some of this work over to Research Association laboratories. For the Council for Scientific and Industrial Research is keenly interested in encouraging the Research Associations to take over work which is of special interest to their members, leaving the D.S.I.R. establishments to cover work of more fundamental interest. But as the Report before us remarks, "The right solution may be a gradual tailing off, with industry and other interested bodies progressively taking over appropriate responsibilities." Already, however, some action has been taken and certain decisions have been made. During the year all work has stopped on the differential analyser in the Mathematics Division, a decision has been reached to discontinue work on refractories in the Metallurgy Division and no further work will be done on glass-working in the Light Division. The future of high-voltage work in the Applied Physics Division is under discussion. To quote from the Report : "Throughout all divisions, continuous pressure has been exerted to concentrate effort on a limited number of important projects." The Report goes on to say "in other cases, the importance of the work to others should be reflected in their willingness to pay for it . . ." In principle, of course, that is a sound proposition. But its application must surely sometimes lead to difficulties. It is obvious enough in many cases that a special service is being granted to one particular firm, as for example when the N.P.L. conducts an independent test of a firm's product. It is also obvious enough that certain other work, whoever proposed it should be carried out, will be fundamental in character. But there must be many doubtful cases, too. Who, properly, should decide, when there is a difference of opinion, whether or not payment will be required before work is carried out ? Our own feeling is coloured by a conviction that it is impossible to estimate the value to the nation of any advance of knowledge however much some individual organisation may seem at first to derive advantages from it. If there is reasonable doubt, therefore, surely the nation, through the D.S.I.R., rather than any individual firm, should pay ; and the carrying out of the work should not be delayed by too stringent an eye upon accountancy.

We hope we have not given the impression that the work of the N.P.L. is being contracted. It is not so. The intention is clearly to make the work of the laboratory more effective by concentrating on work it is particularly fitted to perform. Moreover new fields for its activities are continually being created. One of the new projects of the Applied Physics Division, for example, is the development of a national centre for neutron source standardisation, a particularly appropriate venture for the N.P.L. Additionally at this laboratory as at others the Council is pressing that the work should make more impact on industry than it does at present. One method of ensuring that industry really knows what is going on is to encourage firms to second staff to the laboratory to accelerate the industrial development of techniques and equipment evolved from pioneering research at the laboratory. Another should be to ensure that information about researches is published in appropriate technical journals and before suitable institutions. It is a common complaint within industry—sometimes unjustified—that research results are too often published in such a form that only specialists in the field concerned can understand them. But certainly if industry is to make early use of more esoteric research results an effort needs to be made by the laboratory concerned to explain their industrial significance or to suggest applications, and to ensure that the information reaches firms and organisations that seem well-fitted to make use of it. It is therefore encouraging to note that at the N.P.L. as at the National Engineering Laboratory (formerly the Mechanical Engineering Research Laboratory) a new post of deputy-director has been created. The deputy-director is to be especially concerned with tackling problems "connected with the effects of N.P.L. work and policy on industry."

"MAINLY METALLURGY"

For some months metallurgical people will have missed from our columns a feature which used to appear regularly once a month entitled "Metallurgical Topics." We suffered a misfortune over those "Topics." Towards the end of 1957 Dr. R. H. Greaves, who had edited the pages ever since the end of the war, intimated his desire, on account of his advanced age, to cease doing so. Within a few weeks of giving up the work, very much to our regret, he died. We secured in his place the services of Mr. R. T. Rolfe who had then recently retired from service with W. H. Allen, Sons and Co., Ltd., of Bedford. We were aware when we did so that we could hardly expect him to carry on the work for many years as his age, too, was quite advanced. But we were quite taken aback—as indeed were all his many friends —when in December of last year he, too, suddenly died.

Frankly we were left in the air, having made no preparations to approach any one else. Temporarily, therefore, the publication of "Metallurgical Topics" had to cease. Now, however, we have secured the services of a new correspondent. He is Mr. T. Henry Turner who until recently was superintendent, metallurgy division, British Railways at Derby, and is well known by metallurgists and railwaymen all over this country and by many people abroad as well. Mr. Turner's interests and specialist knowledge spread over a wider field than metallurgy alone; it is his intention therefore in contributing to our pages to report on and comment upon activities which will include certain other subjects besides the strictly metallurgical. We have, therefore, decided upon a change of title for the feature. The first of Mr. Turner's contributions appears on page 846. It is entitled "Mainly Metallurgy." It is the intention that this feature shall appear regularly in the last issue of every calendar month.

EDUCATION FOR DESIGN

We remember some years ago being taken into a works and shown with pride a redesigned small steam pumping set designed for use by native and unskilled workers overseas. The set had originally been designed many years earlier to stand up to almost any degree of ill-treatment. It had no pretensions to beauty; but it had an honest-to-goodness appearance of functional fitness for purpose. Redesigned it was a horror! For, in effect, all that had been done was to place "streamlined" covers over everything, thereby reducing accessibility, and making the thing look suited to "fly through the air with the greatest of ease." Editors are often placed in embarrassing situations. It was made obvious to us that we were expected to express loud praises!

Manufacturers still make the same kind of mistake to this day. But we think it is becoming less common. Part of the reason why it is becoming less common can unquestionably be traced to the work of the Council of Industrial Design. For long that body has been working unceasingly to raise appreciation within industry not only that there are artistic virtues in good design but that well-designed products cost no more to produce and sell more easily. An indication of the growing success of the Council's work was provided last week at a Conference on the "Training of Industrial Designers (Engineering)" held at the headquarters of the Federation of British Industries in London. The Conference took root from an inquiry made by the F.B.I. Industrial Art Committee into the needs and views of F.B.I. members in the light engineering industries for and about the training of designers who have to deal with appearance and ease of operation and maintenance of engineering products. It was organised by a Joint Working Party of the Association of Art Institutions, the Association of Technical Institutions, the Council of Industrial Design and the F.B.I. Industrial Art and Education Committees. It is, of course, very seldom that any such Conference produces any clear-cut conclusion, and this one was no exception. They are not intended to do so. Their purpose, rather, is to clear the air. It is a very necessary aim when the subject of discussion covers simultaneously engineering and the arts. For one of the things that tends to confuse people brought up with a predominantly scientific and technological education is the lack of anything very definite about the arts. One can calculate decisively whether a bridge is capable of carrying a given load; one certainly cannot calculate whether its visual appearance will or will not be satisfactory. For a matter of personal taste is involved. Moreover artists for so long have been accustomed to turn up their noses when in company with engineers that the latter have either developed an inferiority complex or adopted an aggressively "fit-for-its-function-must-be-beautiful" attitude. Actually, in our view, there is only one way to ensure that something will be well designed; its designers must have become accustomed to looking at well-designed articles! Nor does it seem to matter very much what those articles are; they need not necessarily be engineering ones.

If a youngster is to acquire an appreciation of good design there ought therefore to be at least some element of "arts" training in his education. Where is he to get it? Should he be trained primarily at an arts college; should arts lectures be introduced into a technical college course; or should there be co-operation between two such colleges? Where do the universities fit into the picture? Since there is now widespread goodwill we have no doubt that such problems will be solved. But there are also problems within a works. No one man can nowadays undertake the whole design of anything other than a very simple product. Design has become a team function and the team designing an engineering product must be primarily made up of men concerned with the technical rather than the æsthetic factors of the object designed. There must, however, be concerned from the very beginning in the design one or more people trained in artistic perception. To get men with such differing casts of mind to work happily together may prove a harder task than to educate them to appreciate good design!

A VOICE IN AFFAIRS

Who would deny that professional engineers are in some respects badly organised? Certain other professions can speak authoritatively and with a single voice on any public matter which concerns them. But is it possible for engineers to do the same? Are there not too many engineering bodies and institutions, each one going its own way? Do the interests of the profession suffer from having "too little water in too many channels"? These matters as they affect civil engineers were commented upon quite forcefully by Professor Pippard in his recent speech at the Institution of Civil Engineers dinner, of which we give details on page 859 of this issue. The professor commented on the close liaison which exists between the three major institutions, which he thought would be more effective as time went on. But there were too many separate organisations, he said. He then stated that discussions were in progress, between the Institution of Civil Engineers and the Institution of Municipal Engineers, with a view to an amalgamation which he hoped "may prove a pattern for other societies which are closely allied to us in achieving the aim of our charter . . . . . without sacrificing, indeed by incorporating, the great traditions created not only by ourselves but by other bodies."

A catalogue of the various professional bodies which serve the interests of those who, in the proper sense of the term, are all civil engineers, must surely reinforce the professor's opinion. The principal ones are the Institution of Structural Engineers; the Institution of Water Engineers; the Institution of Highway Engineers; the Institution of Public Health Engineers, and the Institution of Municipal Engineers. Would not better professional service be given if some sort of amalgamation, equally active in each field, but nevertheless co-ordinated with the parent institution, were achieved by this multiplicity of institutions? And would it not be that the civil engineer would then, as Professor Pippard suggests, have a greater influence to "bring to bear upon the conduct of affairs"?

THE GUILD AND ENGINEERING APPOINTMENTS

Elsewhere in this issue we note that the functions of the Professional Engineer's Appointments Bureau, originally set up in 1945, largely through the activities of the Institutions of Civil, Mechanical and Electrical Engineers, are to be transferred to the Engineer's Guild. The Bureau was never controlled by the Institutions; under their Charters, those bodies are unable to engage in activities directly benefiting individual members. But the Institutions nominated suitable people from amongst their members to serve on the independent Board which rules over the destinies of the Bureau. For our part we have long felt—even though in 1945 we welcomed the creation of the Bureau as a good thing in itself—that the Bureau would be more appropriately placed under the ægis of the Engineer's Guild than under the decidedly indirect influence of the Institutions. But at the time of its creation the relationship which ought to rule as between the Institutions and the Guild was far from securely established; and, indeed, the Guild itself was still insecurely rooted. There may even be some truth in the idea that the Institutions stepped in to encourage the creation of a Bureau lest the Guild should do so first! Happily, since then, the situation has altered. It has, in fact, so far altered that in agreeing that the functions of the Bureau shall be taken over by the Guild, the Institutions have yielded little of their former indirect influence over its affairs. For they are nowadays strongly (though indirectly) represented on the Council of the Guild itself. Of course, the immediate advantage of placing the Bureau under the Guild is that that body is already intimately concerned with the pay and conditions of service of professional people. The Guild and the Bureau are thus likely both to benefit from association.

LISBON TRADE FAIR

To-day there opens at Lisbon in Portugal a British Trade Fair. The holding of this Fair is especially well timed because it opens just at the start of a six-year plan for the development of Portugal. It is also well timed because though United Kingdom exports to Portugal have steadily increased since the war (apart from a slight fall in 1958), the U.K. share of total imports has fallen. Except for that country's oversea possessions, the U.K. remains Portugal's best customer. It absorbs 14·4 per cent of its exports. But whereas soon after the war Britain exported more to Portugal than any other country, Western Germany has since supplanted it. In 1956 Western Germany supplied 16·1 per cent of total imports; in 1957, 16·7 per cent. In the same years the U.K. supplied 13·6 per cent and 13·3 per cent. The value of British exports to Portugal in 1958 was more than £21,000,000.

Amongst exhibitors at the Fair, we notice that exporters of capital goods are particularly prominent. Indeed, it appears that the market is not a very good one for consumer goods, though some goods of that kind have been selected for exhibition. Engineering firms are strongly represented. The organisers believe that the range of products displayed will help to show what the U.K. can offer Portugal to assist in achieving her objectives under the Development Plan. Quite clearly many engineering firms in this country believe the same thing. Nevertheless, we intend to take little further notice of the Fair. For in comparison with our total world-wide circulation that in Portugal is small; and the Fair must prove its value by attracting attention in Portuguese, rather than British, journals. That value will be much increased if high executives of exhibiting firms will take the trouble to visit Portugal while the Fair is in progress. We hope they will. The Fair will remain open until June 14.

"THE IRONMONGER" CENTENARY

To-day, we take pleasure in adding our congratulations to the many which *The Ironmonger* is receiving on completing its first century as a trade newspaper. We are confident that our readers will endorse our congratulations, for to many of them *The Ironmonger* is no stranger. For a hundred years, that journal has been regularly recording and commenting upon the multifarious activities of an important trade which handles the end products of a host of engineering and allied concerns. *The Ironmonger* developed as a regular trade newspaper from the price list of Morgan Brothers, who were for years in business in the City of London as hardware factors and chemists' sundriesmen. That price list became *Morgan's Monthly Circular and Metal Trades Advertiser* on May 31, 1859, the title being changed three months later to *The Ironmonger*. For the first nineteen years it appeared monthly; since April, 1878, it has been a weekly. Over the past thirty years, we are happy to record, *The Ironmonger* has been published by the company which also owns THE ENGINEER, and on the board of which there continue to serve direct descendants of the founders of both journals. To commemorate its centenary, *The Ironmonger* has produced a handsome special number. The articles contained in it do much more than record the social influence and technical progress of the hardware and metal trades over the years that have passed since 1859. They emphasise very effectively the significant contribution which those trades are making to-day to this country's industry. The foreword to the centenary number modestly says that *The Ironmonger* claims no particular virtue for its antiquity. That may be. Nevertheless, it can deservedly be proud of its continuity.

The Engineer—100 Years Ago (MAY 27, 1859)

"FLOATING DOCKS"

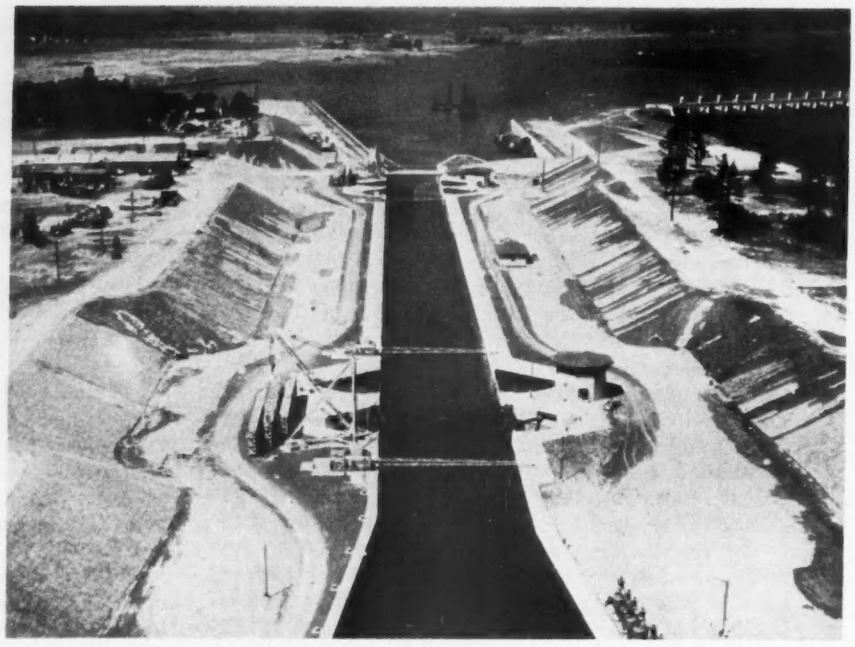
"A prospectus has appeared for the formation of a company for the construction of Maekelean's ship-lifts—an arrangement of pontoons which may be filled and sunk, and which, after a vessel has been brought over them, may be again floated with their load. The lift is described as formed of a number of air and water-tight pontoons, placed side by side afloat, with a timber platform placed upon them. Ten such pontoons, each 50 ft. long, 10 ft. wide, and 6 ft. deep, placed side by side at intervals of 5 ft. apart, would form a floating platform 145 ft. long by 50 ft. wide, with a lifting power of 850 tons. On each side and upon this platform are erected columns and stays, with steps to stay the vessel as she rises, and with platforms and paths for the workmen. Stancheons can be fitted to these columns to carry a roof, if required, over the vessel. The whole is guided vertically by breast shores, with rollers on the columns of the platform. The pontoons are pumped out either from the ship or from pumps worked by an engine on the wharf alongside. It is obvious that each essential part of the lift can be detached from the others, and the whole thus removed with comparative ease to any distance.

"Should the organisation of the proposed company be effected, we have no doubt that the floating docks will be found extremely simple and advantageous, both in construction and working; and for foreign and remote ports we believe the arrangement will prove especially valuable. If additional docking facilities be needed in London, what must be the want in the hundreds of distant ports, other than the leading commercial cities, to which so large a tonnage and value of our shipping are constantly trading? To many of these points, where the difficulties of construction would be very great, the floating lifts could be easily carried and readily set up."

St. Lawrence River Development

I—Navigation and Power

The series of articles which will appear under this title will review principally the engineering works involved in constructing the St. Lawrence Seaway and the power stations associated with it. These works are in three broad categories, namely for navigation, for hydro-electric power, and for re-establishing road and rail communications. Since the opening of the Seaway draws attention to the unique water power potentialities of the St. Lawrence and Niagara rivers, the series includes description of the principal power stations along their banks. Specific engineering works are dealt with in subsequent parts; in this introductory article, a survey along the whole of the Seaway route is given. On the right is the Iroquois lock, with the Iroquois barrage in the right background.



THE opening this year of the St. Lawrence Seaway has aroused widespread interest throughout the world. The Seaway is vast in size, allowing ocean ships to penetrate 1500 miles into the interior of the North American Continent, and making possible the generation of great quantities of electrical power. But it is also noteworthy as a joint venture of two nations, and because it has been constructed in the short period of four years. It was opened to shipping last month (as recorded in a "Leader" in our issue of May 1) and the Great Lakes are now accessible to ocean ships. The formal inauguration ceremonies, will, however, be held in June when Her Majesty the Queen will sail along it.

Navigation on the St. Lawrence River has always been an important feature in the life and history of Eastern Canada, and the Seaway constitutes, in part, an improvement or replacement of other canal systems. But the enormous investment needed to bring the scheme to finality has only been possible because of the profitability of hydro-electric power; the power-generating aspect of the Seaway has, in fact, borne the majority of its cost.

Strictly speaking, the term "Seaway" refers only to the navigational works but here we include information on the power schemes, and also the associated power development of the Niagara River. An understanding of the lay-out and problems of this whole series of projects can best be given by following its course on the accompanying maps (Figs. 1 and 2). In the paragraphs hereunder the principal engineering works from Montreal to Lake Erie are enumerated.

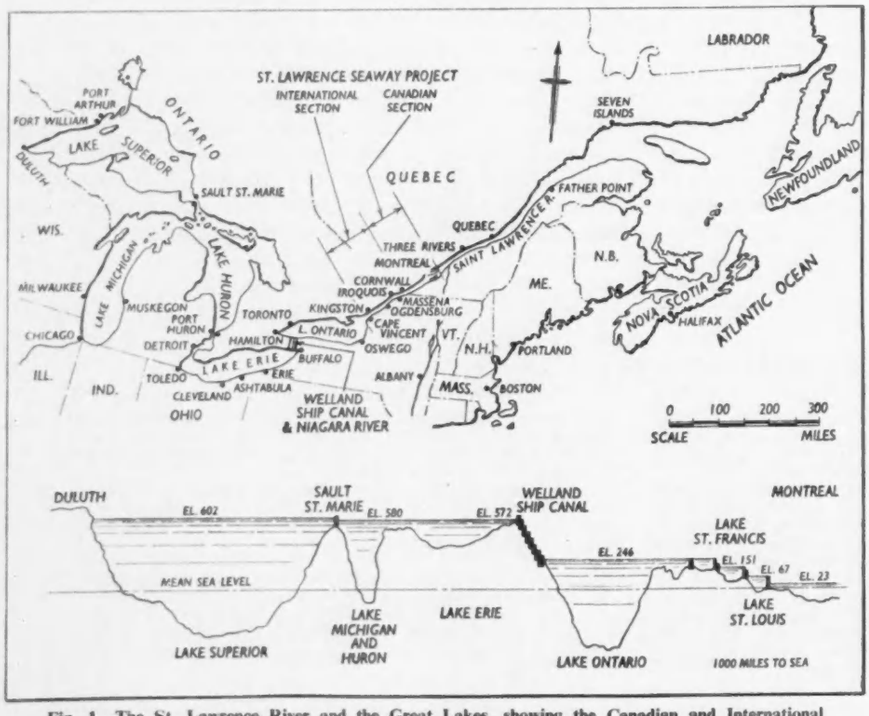


Fig. 1—The St. Lawrence River and the Great Lakes, showing the Canadian and International sections of the Seaway

The St. Lawrence Seaway

The basic aim of the Seaway is to allow navigation for ships drawing 27ft of water, and the possibility of increasing this depth to 30ft later on by dredging. A dredged channel already existed in the St. Lawrence from Quebec to Montreal, to serve the port at Montreal, and the new works of the Seaway commence a short distance downstream from the port, on the South shore of the river. The new construction is virtually concentrated in the length of about 200 miles from this point to Lake Ontario. The Welland ship canal, between Lakes Erie and Ontario, has been modified so that 27ft depth is available, but these works are of a minor nature in relation to the rest of the project, and were, in fact, envisaged when the Welland canal was built.

The first stretch of the Seaway canal then, takes a broad sweep round the shallows close to the southern shore of the river at Montreal (Fig. 2.) Considerable reclamation has been achieved here, the canal being formed by embankments, and thus an area formerly open to the river enclosed between the inner embankment and the shore. From the downstream end, the first work is an extensive area of dredging in the river, to form a turning basin. The Jacques Cartier bridge has been raised where it crosses the Seaway, to give the stipulated headroom of 120ft. The next major construction along the canal

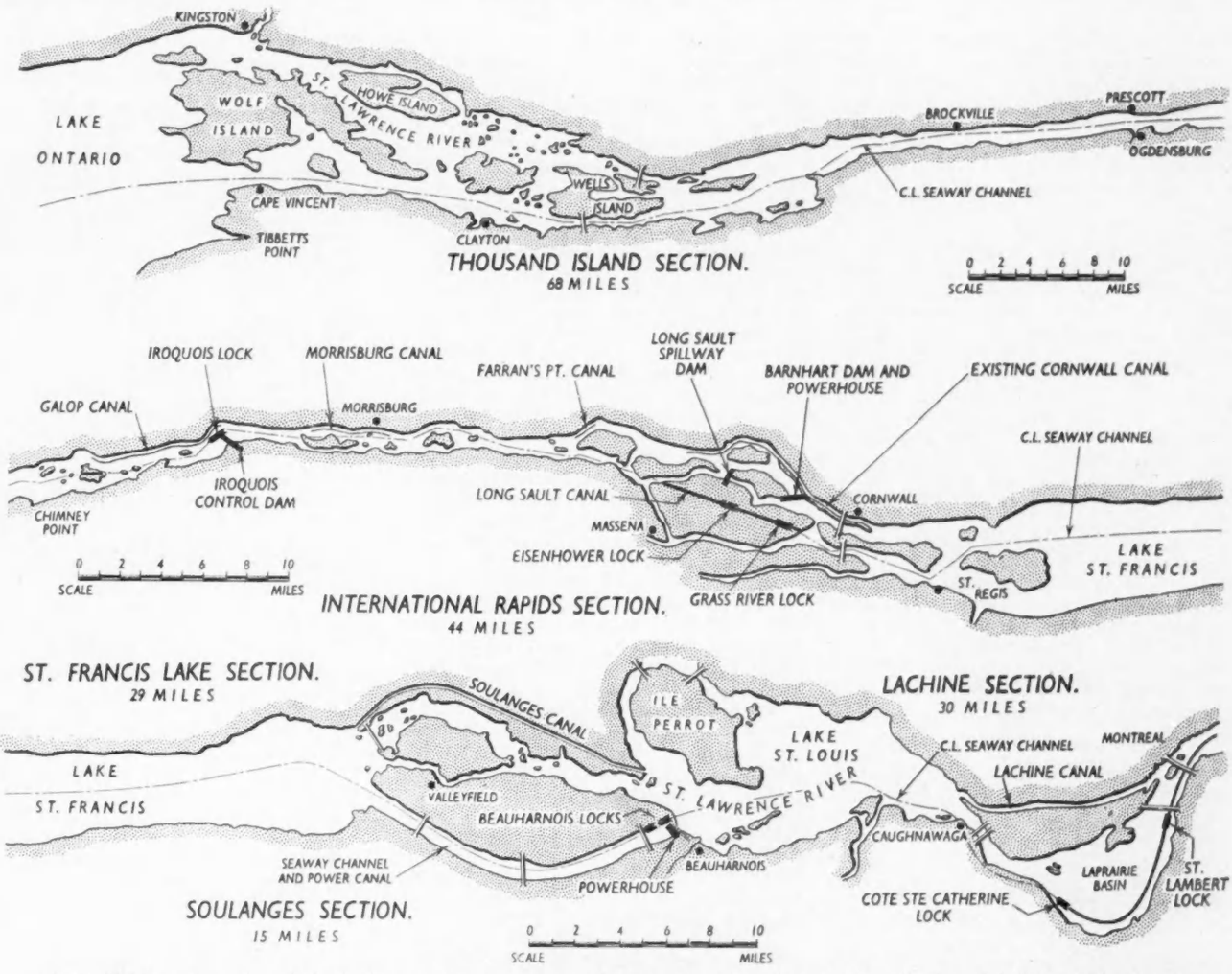


Fig. 2—The five main sections of the St. Lawrence Seaway and power development are shown here, together with the principal constructional works for power and navigation

is the St. Lambert lock. This was, in fact, probably the most difficult of all the Seaway works to construct, for the site is extremely congested, with major road and rail routes at the Victoria bridge crossing the site ; lifting road and rail bridges have been built at the lock, and the old bridge piers underpinned, all of this being achieved while keeping the road and rail routes open.

Proceeding up the Seaway canal, as it sweeps round the Laprairie basin, construction includes turning basins, reconstruction of the South shore drainage, water inlets and sewage outfalls, and substructure works for a future bridge, as well as the canal itself. The second lock is at Cote Ste. Catherine, at a site close to the Lachine Rapids. The disposition here—just upstream of the lock —includes a reservoir for locking water and allows for possible port development works beside the Seaway, and also for the construction later on of a hydro-electric barrage at the rapids. Upstream from this region the canal is excavated from the southern shore of the river.

Two further bridge crossings involving extensive reconstruction are then reached, at the Honore Mercier road bridge and Caughnawaga railway bridge. The canal then leads into Lake St. Louis, where dredging works complete the passage of the Lachine section, which extends over 31 miles to the upstream end of Lake St. Louis.

The next section of the Seaway—the Soulanges section—is 16 miles in length and rather different in character. It makes use of the enormous canal of Beauharnois power station and, in fact, all the constructional work (except for dredging in Lake St. Francis, and two movable bridges on the canal) is concentrated close to the power station. Two locks, with an intermediate basin between them, have been built, and road and rail routes reconstructed. This has been going on at the same time as, but independently of, the third and final extension of Beauharnois power station. Thus, the works at this site alone would have constituted a project of very considerable size.

The next section—the Lake St. Francis section—is 20 miles in length ; the sole works involved are dredging. The crossing of Lake St. Francis brings one to Cornwall, where the U.S. boundary joins the St. Lawrence. All the works so far described have been entirely Canadian, but one now comes to the international section of the scheme, for the river from Cornwall to Lake Ontario forms the boundary between the two countries.

The International Rapids section of the Seaway extends 44 miles upstream from Cornwall, and includes the remaining constructional works. Navigation is directed to the South shore, where the canal passes through two locks — the Snell and Eisenhower locks—both built by the United States. The main river channel on the North side is closed by the vast St. Lawrence generating station, which is a joint venture, half of its power going to each of the two countries. Control of the river level at this point is completed by the Long Sault dam, which closes the channel to the south of Barnhart Island and is, again, a United States structure.

In the regions above this complex of dam, power house and locks, extensive flooding has taken place and, with it, considerable work has been done in re-routing roads and railways, and in resiting villages and towns. This has been necessary as far as Iroquois, which is about 25 miles further upstream and to which the " power pool " extends. Amongst this work of rearranging the facilities of the flooded areas, there has been one major bridge construction, a suspension bridge just downstream from the power station.

At Iroquois, the navigation channel is on the Canadian side of the river, and it passes through the last of the Seaway locks. The main river channel is here partially controlled by a barrage—the Iroquois dam—which is, again, a United States structure. Extensive dredging and excavation upstream of Iroquois was needed to make an acceptable navigation channel at the upstream end of the International Rapids section. From here to Lake Ontario, a distance of 68 miles, is the Thousand Islands section, which is characterised solely by dredging.

To sum up, the principal works involved, in the main length of nearly 200 miles, have been the construction of seven locks, two dams, and a power station of 1040MW capacity. Excavation and dredging have extended over lengths of 37 miles and 71½ miles, respectively. There have been eight major bridge works involving either new bridges or reconstructions, plus the installa-

tion of two rolling lift bridges at locks and various road reconstructions. New towns and villages have been created to replace those flooded by the "power pool" and about 6500 people have been rehoused. At the same time, the last extension of Beauharnois power station, totalling nearly 600MW (total installation 1670MW) has been carried out. Future extensions envisaged are the doubling of all the locks when traffic justifies it, extensive quays and dockside facilities at Cote Ste. Catherine, and a major power station at the Lachine Rapids. The estimated costs of those works already completed, i.e. purely for navigation and excluding the improvements at the Welland canal, is given as 300 million dollars for the Canadian works, plus 130 million dollars for the U.S. works. The estimated cost of the power generating works at the International Rapids (excluding entirely the Beauharnois power station extension) is 600 million dollars, divided approximately equally between the U.S. and Canada.

Thus, the power and navigational works directly carried out for the Seaway project between Montreal and Prescott, altogether account for a cost of some 1030 million dollars. Improvement of the Welland canal has cost, in addition, 25,000,000 dollars. But other works, too, are involved in enlarging the various Great Lakes ports on which large sums are being spent.

Earlier St. Lawrence Canals

It is considered by historians that Montreal owes its position and a good measure of its early influence and growth to the Lachine Rapids. The rapids were, in fact, the first obstacle to navigation encountered by Jacques Cartier in his search for the North West Passage and, because they formed the limit of ocean navigation, so the settlement of Montreal sprang up. The first attempt to circumnavigate them dates from 1700, when a canal of 18in depth was constructed at the Little River St. Pierre, near Lachine.

In 1780 and 1804 short side canals of 2ft to 3ft in depth were constructed at the edge of the rapids. The huge freight-carrying "canots de maitre" of the fur-trading companies used these canals. In 1821 the first Lachine canal proper was undertaken. It had a depth of 5ft, but was deepened to 9ft between 1843 and 1848. A second and last enlargement, between 1870 and 1883, provided a 14ft depth throughout. The Lachine canal, now 8¾ miles long, has a total lift of 50ft and gives access from the Port of Montreal to Lake St. Louis. It will be practically completely superseded now that the Seaway canal has come into use.

Considering now the Soulanges section which extends from deep water at the head of Lake St. Louis to deep water at the foot of Lake St. Francis, we find that between 1779 and 1783, the Royal Engineers constructed four side canals with locks 6ft wide, giving 2ft 6in depth to overcome the Cascades, Split Rock, Cedars and Coteau Rapids, in ascending order. The Beauharnois canal, on the southerly shore, built between 1842 and 1845, replaced these earlier canals and provided 9ft navigation. It, in turn, was replaced by the present Soulanges canal on the opposite side of the river, begun in 1892 and completed in 1899. It has five locks, a total lift of 84ft and provides 14ft navigation. The power canal at Beauharnois for the hydro-electric development was completed, to the first stage designs, in 1932, and gives a 27ft channel, which is now available with the completion of the new locks.

In the International Rapids section there is a total difference of water level of some 92ft which was overcome by a series of canals. The first of them, proceeding up-river, is where a 9ft canal was built between 1834 and 1842 at Cornwall. This canal was enlarged to 14ft depth between 1876 and 1900. Next in order upstream is the Farran's Point canal, first built between 1844 and 1847 and enlarged to 14ft depth between 1897 and 1901. The Rapids Plat canal at Morrisburg, constructed at the same time as the canal at Farran's Point, was enlarged to 14ft draught between 1884 and 1904. The last in the series of canals in this section is the Galop canal at Iroquois. Construction of this canal for 9ft navigation was completed in 1848. This canal was later enlarged to 14ft depth and completed in 1908.

Between Lake Ontario and Lake Erie there is a difference in level of 326ft along the Niagara River, its rapids and Niagara Falls. This is overcome by the Welland Ship Canal, which crosses the Niagara Peninsula 10 miles west of Niagara Falls. It is some 27 miles in length. The first canal here was built by a private company between 1824 and 1833 and had a depth of 7ft 6in. This canal was later taken over by the Government of Upper Canada and enlarged to 9ft depth between 1842 and 1850. Its completion coincided with the completion of the St. Lawrence canals in 1848 and permitted vessels 140ft long, of 26ft beam and 9ft draught to ascend for the first time from Montreal to Lake Erie. Construction of the third Welland Canal was begun about 1873 and completed for 14ft navigation in 1887. It required twenty-six locks to accomplish the 326ft lift.

In 1913 work was begun on the Welland Ship Canal. Construction was suspended in 1916 but was resumed after the war and completed in 1932. The lift from lake to lake was accomplished with only eight locks as against twenty-six in the 14ft canal. Seven of these eight locks are 859ft long and one is 1380ft in length. All are 80ft wide, with 30ft depth over the lock sills. Before the Seaway scheme had been started, the available depth was 25ft, although about 17 miles of the canal had a draught of 27ft. Dredging has now brought the entire canal to a 27ft depth.

The Niagara Power Stations

It will be seen from the foregoing that the principal sites for the generation of water power on the St. Lawrence River are at Lachine Rapids which have not yet been developed (corresponding to the first two locks of the Seaway) at Beauharnois (corresponding to the next two), and at the International Rapids section where the new power station has been built. At Niagara, there is, of course, another major source of power which has been progressively developed over many years. The most recent developments in this area include pumped storage schemes. On the Canadian side, hydro-electric development is complete, with the Sir Adam Beck Niagara Nos. 1 and 2 stations generating the great bulk of the power, but with a pumped storage station and reservoir built above the forebay of these two stations. On the U.S. side corresponding developments are under construction, with the main power station at Lewiston, and above it the Tuscarora pumped storage station and reservoir. We include later on some information about these schemes, along with a brief reference to the Welland Ship Canal. Thus, the exploitation of the St. Lawrence, both for navigation and power, is traced from the sea to the Great Lakes in a comprehensive way.

Hydrology of the St. Lawrence

A few leading figures for the hydrology of the St. Lawrence River should be included a this introductory stage, to give an idea of the magnitude of the river, and the scope of its exploitation. Table I shows some of these

Table I—*Hydrological Data for the St. Lawrence River*

Catchment area of St. Lawrence River and Great Lakes Basin	295,000 square miles
Area of the Great Lakes	95,000 square miles
Length of shore line of Great Lakes	8300 miles
Surface levels of the Great Lakes :	
Lake Superior	602ft above sea level
Lakes Huron and Michigan	580ft above sea level
Lake Erie	572ft above sea level
Lake Ontario	246ft above sea level
Flow figures for the St. Lawrence River :	
Extreme maximum monthly mean flow	315,000 cusecs
Extreme minimum monthly mean flow	154,000 cusecs
Average flow	241,000 cusecs
Controlled discharges from Iroquois dam :	
Maximum during navigation season	310,000 cusecs
Minimum during navigation season	180,000 cusecs
Minimum dependable flow during autumn and winter	205,000 cusecs
Flow ratio maximum : minimum	2
Flow ratio with control at Iroquois	1·7
Flow from Ottawa River :	
Maximum	323,000 cusecs
Minimum	16,000 cusecs

figures, including catchment areas and river flows. Apart from sheer size, the river is unique in the evenness of its flow, the ratio between extreme flows being about 2 : 1. The natural reservoir of the Great Lakes is, of course, the governing factor in this regularity. So the St. Lawrence provides not only a major source of power and a facility for navigation, but also regulates itself quite effectively. In fact, no major attempt at creating storage on a large scale has been made in the Seaway project. The Iroquois dam offers a degree of control of the flow, so that some regulation of the output of the power stations below it is possible, and in particular, a "firm" flow is stipulated for the autumn and winter when the peak loads are highest. Nevertheless, all the Niagara and St. Lawrence River power stations are essentially run-of-river installations.

The following points may be noted in explanation of Table I. The total length of "water highway" which the Seaway scheme opens up is 2300 miles. The difference in level between Lakes Superior and Huron is taken up at an existing lock in the St. Mary River. However, no locks are needed between Lakes Huron and Erie, where the 8ft difference in level is distributed through Lake St. Clair and the St. Clair and Detroit rivers. The only really large drop in the system, from Lake Erie to Lake Ontario, is, of course, taken up by the Welland Ship Canal. Below Lake Ontario, the St. Lawrence River extends 1200 miles to the sea. It may be considered virtually an extension of Lake Ontario for 68 miles to Chimney Point. From here, for 119 miles to Montreal, the river level drops from 243ft to 23ft above sea level. This drop is virtually concentrated in three short sections : the 44 miles International Rapids, the Soulanges Rapids and the Lachine Rapids, which, of course, correspond to the three major sites for the Seaway works and for power generation. The heads lost in these three reaches are respectively about 92ft, 82ft and 50ft. The Ottawa River discharges partly into Lake St. Louis and partly into the St. Lawrence below Montreal; the discharge into Lake St. Louis is appreciable only when the river is in flood.

The flow figures quoted here are based on records which go back for almost a hundred years. Discharges were actually measured first in 1900, but discharge can be related fairly simply in the St. Lawrence to "stage," or level, and so earlier figures were obtained. Extensive hydraulic model studies were needed to supplement this recorded data of the rivers' behaviour, and model investigations were in fact carried out for each one of the important reaches of the rivers. This work, together with other interesting aspects mentioned here, such as the storage and

control problems at Iroquois, will be referred to more fully in subsequent parts of this series.

Geology of the Seaway Route

The geology of the St. Lawrence valley seems almost to match the unrivalled advantages of the hydrology of the river, in presenting a favourable background for engineering works. To give a brief overall picture of the geology and soil mechanics of the Seaway project, we have abstracted the following general description from a paper* by Messrs. Peckover and Tustin, in which the very extensive exploratory programme of test drilling, &c., is described.

"The St. Lawrence River valley has been subjected to at least two glaciations, followed by an inundation by the sea and, finally, uplift above sea level. During glaciation the bedrock surface was reduced in relief and dense glacial till laid upon it, ranging in thickness up to 100ft but usually of the order of 20ft to 30ft.

"Till deposits of the first glaciation are found all along the Seaway route, but those from the second are found only in the International Rapids section and at scattered locations in the Lachine section. Between the two deposits, lacustrine clays and poorly graded sands and gravels are occasionally present. In the river bed, fines from the upper layer of till have been washed out, leaving a mixture of coarse sand, gravel and boulders.

"During submergence by the sea, the till was covered by a deep bed of marine clay, capped with marine sand. As the land surface emerged above sea level, the sand and clay was removed by erosion except for local remnants, the most important of which are at Beauharnois and Cornwall along the Seaway route.

"The till generally is a most useful construction material, as shown by its inclusion in nearly all dykes and its use as a seal on all rock cofferdams. It is a dense, well-graded soil mixture appearing with approximately equal silt, sand and coarse fractions in a typical sample. Wide variations occur in the proportions of silt and sand.

"The marine clay found at Beauharnois and Cornwall is relatively weak and soft in its natural state and becomes very soft and sticky when disturbed by excavation. The weathered portion of this deposit is suitable for compacted fill. The unweathered portion may be considered as a general liability in construction operations.

"The stability of the bed of the St. Lawrence River can be attributed to the resistance to erosion of the glacial till and the bedrock formations of which it is composed. The river flow is controlled at intervals by outcropping ledges of the more resistant rock. A series of rapids and intervening pools is thus formed between Cornwall and Montreal. The rapids of the river, skirted by canals and locks, are thus separated by broad reaches such as Lake St. Francis and Lake St. Louis which require only dredging for improvement for navigation.

"Bedrock which occurs along the river between Lake Ontario and Montreal is mainly sedimentary. Igneous rock is found in the Thousand Islands section and as intrusions in some of the sedimentary beds. The latter include shale, limestone, dolomite, sandstone and various combinations of these. From the viewpoint of foundation quality, the bedrock is relatively free from large fault zones or folding. Bedding is generally horizontal with local dips not exceeding 10 deg.

"The limestone and shale from channel excavation were used extensively in embankment and dyke construction. The shale is a cemented non-plastic rock which disintegrates into angular particles on exposure to air. Since broken shale was readily available for use in pervious zones of the dykes, detailed studies of old shale dumps in the area were made. These confirmed that weathering of the shale does not reduce it to an impervious condition.

"In the course of design and construction, the problems encountered have touched on almost every aspect of the soil and foundation field. The nature of the work, however, laid heavy emphasis on problems of excavation, construction of fills, the stability of slopes, ground water and drainage, and foundations for large structures. Other problems were generally offshoots of these major considerations."

Legislation for Navigation and Power

Special legislation was enacted both in the United States and Canada to form official bodies with the power to carry out the various constructional works. On the Canadian side, the responsible agency is the St. Lawrence Seaway Authority. The parallel agency in the United States is the St. Lawrence Seaway Development Corporation. These two organisations are responsible specifically for the navigational aspects, and not for hydro-electric power, and they are empowered by respective legislation in the two countries to co-operate with each other, first in design and construction, and then in operation and maintenance of the Seaway. In practice there is a difference in the procedure of the two, in that the Authority employs its own engineering staff, and has directly carried out the design of its sections of the Seaway and supervised the construction, under the direction of its chief engineer, Mr. A. G. Murphy. The Corporation, however, appointed the U.S. Corps of Engineers as its agent for design and construction, and as consulting engineers Messrs. Uhl Hall and Rich.

Hydro-electric development in the International Rapids section also involved both countries, and here the responsible Canadian organisation is the Hydro-Electric Power Commission of Ontario. The corresponding organisation in the United States is the Power Authority of the State of New York. Again, these two bodies have co-operated together, and with the two navigational bodies, to ensure designs which satisfy both interests. The Power Authority of the State of New York was, in fact, created for this special purpose of utilising U.S. benefits from the major source of water power at Cornwall. The water power resources at Niagara are also the responsibility of these two organisations. Further down the river, in the Canadian part of the scheme, the Seaway is being built in conjunction with another major power station at Beauharnois, and a site for a third exists at Lachine. In this part of the river the power potentialities are the responsibility of the Quebec Hydro-Electric Commission.

Tolls

Two major factors which encouraged the promotion of the Seaway (apart from general economic growth) were doubtless (*a*) increasing demands for electrical power, and (*b*) plans for exploiting the vast iron-ore resources in Labrador and refining them at the U.S. industrial centres around Chicago. But many other factors could be cited to justify the existence of the Seaway. However, in common with most projects which aim at a fundamental change in economic circumstances, the precise scale of benefit which will accrue from its use had proved difficult to estimate, and of course all the controversy about the merits and need for the Seaway centres on this very point.

The decision was taken at an early stage that the Seaway should pay for the cost of its construction by exacting tolls from vessels using it. A commission was appointed to examine how the tolls should be fixed, and it published its report last June. The toll system aims at simplicity, and encouraging traffic, and appears to compare very favourably with the charges

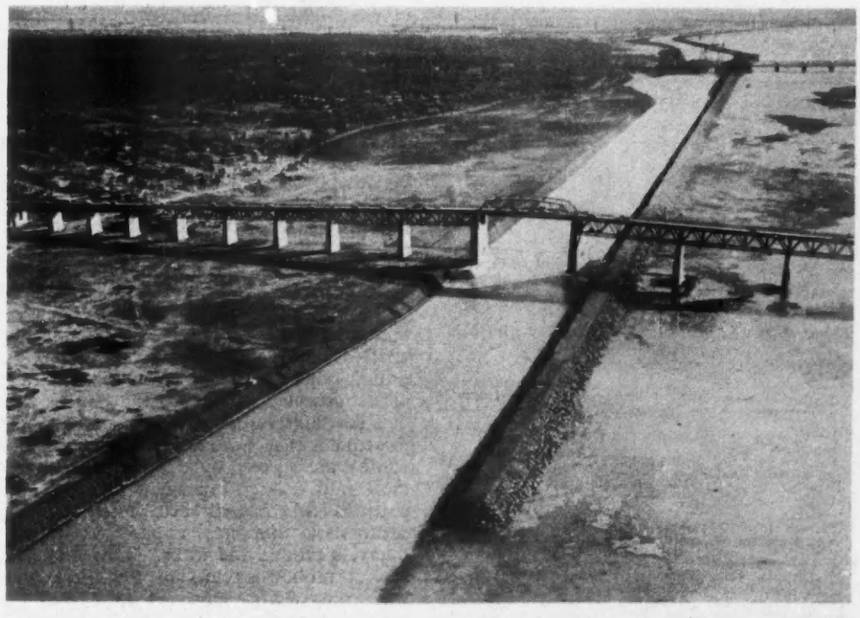


Fig. 3—The Seaway entrance, showing the raised Jacques Cartier bridge, reclamation on the South shore and, in the background, the St. Lambert lock and the Laprairie basin

* "Soil and Foundation Problems of the St. Lawrence Seaway Project," by F. L. Peckover and T. G. Tustin, *The Engineering Journal* (published by the Engineering Institute of Canada), Vol. 41, No. 9, September, 1958. *The Engineering Journal* has published a considerable number of articles, contributed by Canadian engineers engaged on the Seaway construction, during the past few years.

made on other major canals. But, as the critics have pointed out, it remains to be seen whether the cost will actually be recovered in this way. A composite toll system is used, the major items in which are enumerated in Table II.

The Constructional Problem

The Seaway has evoked a great number of superlatives from those who have described it. Generally, the opinion is held that it is the largest scheme of its kind which has ever been undertaken. Here we give some idea of its magnitude and scope by listing in the accompanying Tables III–VI (*a*) the requirements for navigation ; (*b*) the potentialities for power generation ; and (*c*) the principal constructional quantities. We also tabulate the facilities for 14ft navigation which the Seaway supersedes, for comparison.

Note particularly the estimated figure for traffic using the Seaway each year. This figure relates to the constructional works now completed, and it remains to be seen whether it will soon be reached and whether or not it will prove necessary in the near future to " twin " the seven locks. If so, the " twinning " near Cornwall will be done on the Canadian side to provide an all-Canadian canal.

From the engineering point of view, the constructional work has involved a tremendous concentration of contractor's plant and workpeople. At the peak period of construction over 20,000 people were employed on the project as a whole. In the design stages, a corresponding effort was needed on the technical side ; as far as the Canadian work was concerned, the scope of the soil testing and soil mechanics programme, on the one hand, and of the various hydraulic model investigations on the other, are considered to have been unprecedented.

Generally speaking, however, the most difficult engineering problems were of organisation and hinged particularly upon keeping progress up to schedule. The constructional programmes set out in many of the major contracts were very tight, and the paramount importance of keeping up to their requirements was the dominant factor of the work. Otherwise, the Seaway did not present undue engineering problems ; its route was largely fixed by the topography of the St. Lawrence (except in the International Rapids section, where political considerations influenced it) and good quality rock was met with for the foundations of most of the major structures.

In ensuing parts of this series, it is our intention to describe in greater detail, the specific engineering tasks involved in constructing the various individual works of this series of vast projects.

(To be continued)

Table II—*Principal Items of Composite Toll System*

	Tolls		
	Montreal to or from Lake Ontario	Lake Ontario to or from Lake Erie (Welland Canal)	Complete transit
	Dollars	Dollars	Total Dollars
1. A charge per gross registered short ton	0·04	0·02	0·06
2. A charge per short ton of cargo :			
Bulk cargo	0·40	0·02	0·42
General cargo	0·90	0·05	0·95
3. A charge per passenger	3·50	4·00	7·50
4. Minimum charges :			
Pleasure craft	28·00	16·00	30·00
Other vessels	14·00	32·00	60·00

Table III—*Principal Quantities for Construction of the St. Lawrence Seaway*

Note : This table includes the navigation works only, and not the St. Lawrence power scheme.

	Dry excavation, cubic yards	Wet excavation, cubic yards	Concrete, cubic yards	Steel, tons
Lachine	38,594,050	7,200,000	910,750	19,150
Soulanges	5,595,000	—	625,000	15,025
Lake St. Francis	—	4,400,000	—	—
International Rapids :				
Canada	4,719,400	7,004,000	282,300	700
United States	25,060,000	4,870,000	1,030,000	19,900
Welland Canal	661,000	1,659,500	—	—
Totals	74,629,450	25,133,500	2,849,050	54,775

Table IV—*Navigational Facilities of the St. Lawrence Seaway*

Depth of navigation channel	27ft
Minimum bottom widths of channel :	
Straight length between embankments	200ft
On curved lengths between embankments	300ft
Straight lengths with one embankment submerged	300ft
Dredged width for submerged channel	450ft
Minimum radius of curvature	5000ft
Minimum distance between curve reversals	1320ft
Maximum current in river reaches	4ft/sec.
Overhead clearance	120ft
Lock dimensions :	
Length	768ft
Breadth	80ft
Depth over sill	30ft
Duration of normal ice-free navigation season	7½ months
Maximum dimensions of ships using the Seaway :	
Normal usage	715ft by 72ft by 25ft loaded draught
Special schedule	730ft by 75ft

Table V—*Power Potentialities of the St. Lawrence and Niagara Rivers*

Power sites	Ultimate potential installed capacity, MW	Head, ft
Lachine Rapids	750	50
Beauharnois	1670	82
International Rapids	1640	92
Niagara River :		
U.S.	2190*	326
Canada	1762*	

Power production is regulated by treaty at Niagara, and 100,000 cusecs is maintained over the Falls on summer days.
* Including, in each case, the capacity of a pumped storage plant of 240MW on the U.S. side, and 170MW on the Canadian side.

Table VI—*Comparison of the Seaway with 14ft Navigation Completed in 1908*

	Seaway	Canals now superseded
Depth	27ft (later 30ft)	14ft*
Number of locks	7†	21†
Size of locks	768ft × 80ft × 30ft	270ft × 45ft × 14ft†
Approximate maximum capacity of vessels	25,000 tons	3000 tons
Traffic capacity per season	35,000,000 to 50,000,000 tons	12,000,000 tons
Journey time between Montreal and Prescott	18 hours	30 hours

* 25ft at the Welland canal and from Lake Ontario to Prescott. In the Great Lakes 25ft for down-bound vessels, 21ft for up-bound vessels. For navigation in St. Lawrence River below Montreal the depth of the dredged channel below low water is 35ft and its minimum width 550ft.
† Not including the Welland Ship Canal ; this canal has seven locks, with dimensions of 859ft by 80ft by 30ft, operating between levels 246ft and 572ft above sea level.

7000-ton Magnet for 7GeV Proton Synchrotron

A 7GeV proton synchrotron is under construction at the Rutherford High Energy Laboratory (Harwell) of the National Institute for Research in Nuclear Science. The 7000-ton electromagnet for this particle accelerator is being built by Joseph Sankey and Sons, Ltd., Wolverhampton. It is a ring-shaped magnet 160ft in diameter and for ease of transport and installation it is being built in 336 sectors, to be completed at the rate of one a day. Each magnet sector is built up of forty-five silicon steel plates, 10ft 5in high by 9ft 3in wide, making a 12½in stack with a ½ deg. taper to suit build-up into a ring. A full description of the procedure for manufacturing this magnet is given here.

THE 7000-ton electromagnet core for a 7GeV (i.e. 7000MeV) proton synchrotron is being built at the Wolverhampton works of Joseph Sankey and Sons, Ltd. This proton synchrotron, which will be the most powerful particle accelerator in Great Britain, is under construction at the Rutherford High Energy Laboratory, Harwell, of the National Institute for Research in Nuclear Science.

Its principle of operation is the same as that of its predecessors, a notable example of which is Birmingham University's 1000MeV proton synchrotron* which was, at the time of its completion, one of the largest particle accelerators in the world. Briefly, the principle is that protons at energies of about 15MeV are injected by a small linear accelerator into a large evacuated torus. These particles are further accelerated by h.f. electrostatic impulses applied at regular intervals around the torus. They complete several million circuits of the torus and, while their energy increases throughout the process, they are subjected to a controlled, rapidly increasing magnetic field which keeps them effectively in a circular orbit. When the particles have reached their maximum velocity (about 0·990*c*) they are projected tangentially at a target. This bombardment of the nuclei in the target produces secondary emissions which are the object of study.

Excitation of the magnet is produced by a water-cooled copper winding, the heat dissipated being 3MW. The main insulation consists of impregnated mica silk tape, with an outer tape of " Terylene," the whole being designed for an applied voltage of 14kV. At the point of injection from the linear accelerator into the torus the particle energy is 15MeV. The corresponding field is 300 gauss and this field is increased to 14,000 gauss in 0·7 second, while the particle energy is raised to 7GeV. The peak current is about 9000A. This excitation will be provided by a twin-motor alternator set, each unit consisting of a slipring induction motor driving a 60MVA (nominal rating) alternator and a flywheel.

In the accompanying cut-away view (Fig. 1) of a model of the Harwell proton synchrotron the equipment for particle injection is repre-

* The Engineer, February 20, 1953, page 271.

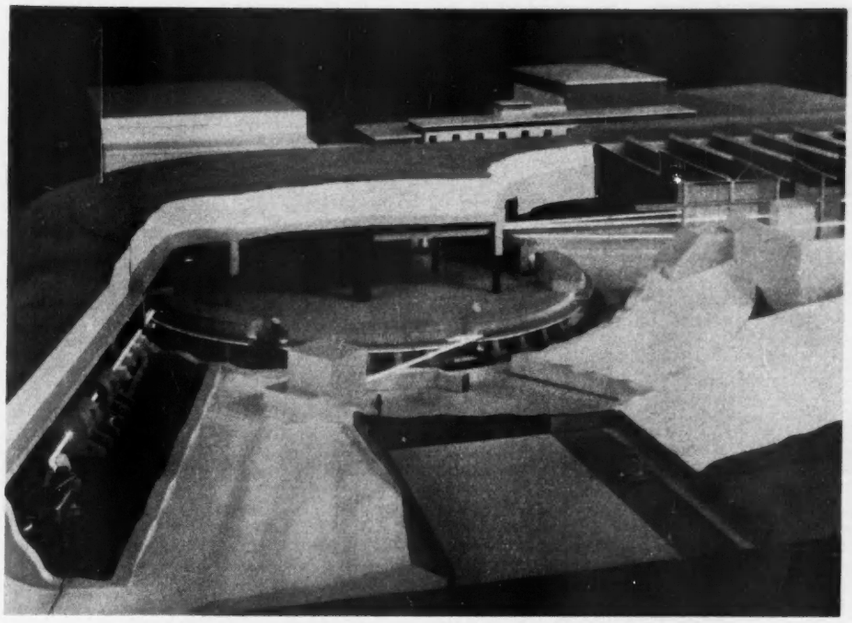


Fig. 1—Sectional model of 7GeV proton synchrotron. The 160ft diameter magnet core weighing 7000 tons, can be seen in the centre and the 15MeV injector on the left. The path of the proton beam is indicated by white lines

sented on the left and the ejection is represented by white lines, simulating the beam, emerging from the torus towards the right.

It will be seen that the magnet consists of a ring divided into eight equal arc-shaped parts separated from each other by eight acceleration zones. Each of the eight sectors is built up of forty-two wedge-shaped sectors. Each of these component sectors is 10ft 5in high by 9ft 3in wide by 12½in thick (with ½ deg. taper on each face to fit) and is built up, as explained below, from forty-five silicon steel plates. In each plate there is a window (Fig. 2) which provides the finished magnet with a channel to accommodate the pole pieces, the magnet winding and the torus. Great accuracy is required in the dimensions and levelling of this channel (within 0·005in of true plan position), in the completed magnet. Some of the manufacturing precautions needed to produce this accuracy are detailed in the following description.

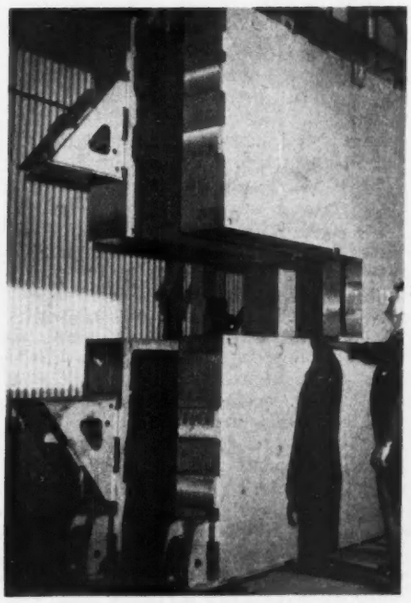


Fig. 2—Two of the 336 magnet sectors required for the 7000-ton magnet core of the 7GeV proton synchroton at Harwell

Plates (¼in and ½in thick) made of 1 per cent silicon steel are each marked for cast, ingot and position of ingot. These are stored and then drawn from stores in such a manner as to "randomise" variations within each cast. A pair of plates are selected and inspected for thickness variations, lamination (or pipe) and surface defects; two sides of each plate are sheared at right angles, the rough profile of the magnet throat is flame-cut out. A magnetic head working from a dowelled template controls the profile shape which is cut at 120ft per hour in ¼in plate and 84ft per hour in ½in plate, using $^{1}/_{32}$in and $^{1}/_{16}$in nozzles respectively. This profile leaves $^{3}/_{16}$in for final machining.

Manufacture of Magnet Sector Plates

When inquiries were first made about the fabrication of the magnet sectors out of 1 per cent silicon low carbon electrical steel, using ¼in thick laminations and ½in thick cheek plates, it was realised that two 5ft plates would have to be welded together, as it was impossible to obtain 10ft wide plate. The specification required weld metal to be approximately the same chemical analysis with 90 per cent of the mechanical properties of the parent plate. The plates after welding must be flat without any puckering; welding must be to full penetration, and no undercutting at the edge of the welds and no thinning down of the plate would be permissible after the penetration and reinforcement weld metal had been removed by grinding.

To meet this specification, a special electrode and a welding jig with heavy clamping were needed and provision was necessary for presetting the plate to allow for welding distortion. As it was difficult commercially to obtain 1 per cent silicon wire, the choice of the welding process was limited to submerged arc or a continuous electrode, where the silicon could be added in the flux. At this stage, Quasi Arc, Ltd., was consulted about the possibility of making a continuous electrode to give a 1 per cent silicon content to be used with their CO_2 process. In a few weeks an electrode was developed and test welds were made and approved by Harwell. When the order for the magnet sectors was placed with Sankeys, the Quasi Arc Company was invited to design a welding jig to weld the two 5ft plates together. The design agreed upon has a total clamping pressure of 60 tons, distributed to twelve individual pads of 12in length, the bed girder being able to withstand these forces without distortion. Four removable water cooled copper backing bars were made with a camber for the correct amount of plate deflection to off-set welding distortion.

The close square butt type of weld preparation is used. Fusarc 8 S.W.G. continuous electrode is used as the filler material with a current setting of 540A at 28–30V. Welding speed is approximately 17in per minute and full joint penetration is achieved; the cambered copper backing bar is also grooved (¼in by $^{1}/_{16}$in) to assist in this connection. With the ½in thick plates close square butt joints are again used, one pass being made from each side. The ½in plates are turned over for welding both sides in a special purpose manipulator designed by Sankeys.

After early troubles with transverse cracks and fissuring attributed to the high silicon and low manganese content of the steel, a satisfactory electrode was evolved and the weld metal analysis was approved by Harwell. "Ardrox" dye penetrant is used as an inspection method.

Weld dressing is in two stages: a mechanised grinder takes off the gross excess, followed by pneumatic hand tools using Tryolite 9in discs to finish and polish. Close control is exercised to stop undercutting below the plate surface.

Annealing.—After plate preparation the plates are annealed to flatten them, homogenise their structure and optimise their electrical properties, by heating a stack of plates in a bell type furnace to about 800 deg. Cent. and cooling.

Twelve months' development work was required to establish a satisfactory annealing process. Difficulty was experienced with buckling of the plates because of their size. In the early stages twenty-six thermocouples were placed at various positions in the stack of plates to enable a satisfactory thermal pattern to be devised. At first, very slow heating and cooling rates (about 3 deg. Cent. per hour) had to be maintained to avoid distortion, but each anneal then took about one month. Eventually, the thermal cycle was reduced to two weeks. The furnace system consisted of the main bell elements to heat the sides of the plate stack (leaving the corners clear), hearth elements and a specially developed throat heating block (Fig. 3). These three groups of elements are controlled individually to keep the thermal differences within predetermined limits.

After trying various forms of cooling hood a design was adopted having an insulated cover with an air gap between the inner shell and the insulation layer. By operating flaps at the bottom of the sides of the hood and on the outlets on the top of the hood, it is possible to regulate closely the rate of flow of air through the gap, and thus govern the rate at which the temperature of the stack falls. It has been found possible to reduce the cooling time under this cooling hood from five days to three days and so meet production rates.

Another difficulty was that the plates are thicker in the centre than at the edges, causing them to be barrel shaped—a characteristic originating from the rolling mill. To correct this defect, the thickness at six positions on a representative number of plates from each cast was measured and

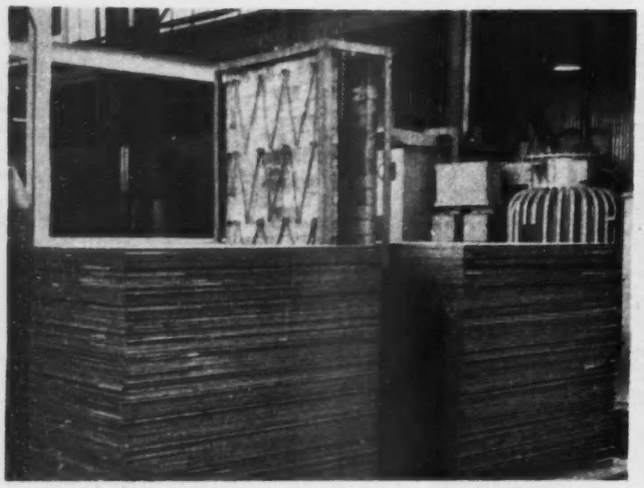


Fig. 3—Magnet laminations stacked, with crown compensation strip at the edges, on a flat base of 1in mild steel plate, level to within ¼in over the whole area of 100 square feet; the full charge weighs 80 tons and is 4ft 3in high. One of the special throat heating blocks is being lowered into position

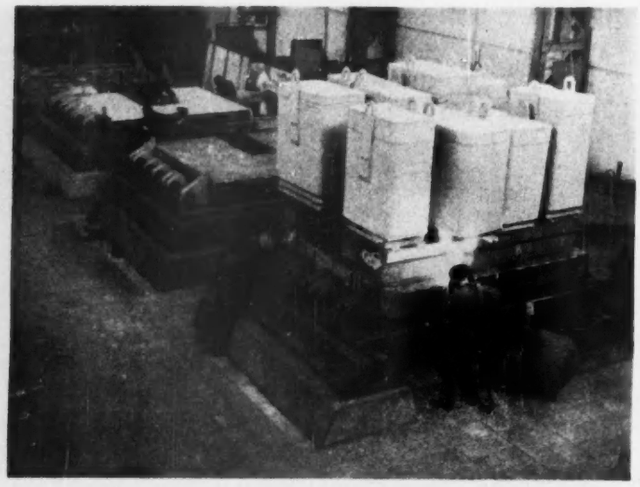


Fig. 4—On nearest of three magnet building beds side plates are being welded on to insulated laminations to form completed magnet sector before machining. The laminations are held flat by 50 tons of weights equally distributed over the sector. On the third building bed each lamination is being insulated

compensation allowed for this crowning effect. As the amount varies from cast to cast, tables have had to be made for each amount of crowning varying from 0·002in to 0·012in. Compensation is effected by inserting at specific positions within the stack of plates, pieces of cold reduced strip, 0·013in thick and widths varying from 3in to 18in. They fit into the gaps on the edges of the plates and support them when they become plastic at the higher temperatures.

The production annealing process is now as follows. The plates are placed on a flat base of 1in thick mild steel plate, level to within ¼in over the whole area of 100 square feet, and are stacked together with the compensation strip to a height of 4ft 3in. The full charge weighs about 80 tons. Twelve thermo-couples are then placed in the charge and the throat heating block lifted into position. An inner cover of 17 per cent Cr steel is then placed over the charge, forming a sand seal at the bottom, and nitrogen gas is introduced to prevent oxidation. The bell furnace, having resistance elements around the four walls and weighing about 20 tons, is then placed over the charge. Together with the base elements and those on the throat heating block the rating is about 500kW.

The temperature of the charge is then raised slowly to reach the final temperature of about 800 deg. Cent. in eight days, all the hearth elements and throat blocks being automatically regulated by programme controllers. At this annealing temperature the plates are roughly 1in longer and wider than they were at room temperature. Cooling then takes place, first, in the furnace and then under the variable insulation cooling hood. The complete cycle from when the furnace is placed on the charge until the cover is removed takes about sixteen days.

When the anneal is completed, each plate must be flat to within $\frac{1}{16}$in over the whole area, otherwise the fabricated sector will not be sufficiently flat. When annealed the plates develop a permeability as follows :—

B in Kilogauss	H in Oersteds
10	About 3½
13	About 6
15	About 10
18	About 90

The coercive force developed is 1·5 to 2·0 oersteds.

"*Randomisation.*"—A sector must contain plates from at least five casts, and these must come from at least four different annealing charges, with all three annealing positions (top, middle and bottom) represented, and all positions within the ingots included. The ingot positions follow automatically from the initial "randomisation" in the preparation bay. From the annealing furnaces the plates are placed on the "randomisation" beds. There are fifteen beds in three rows of five and any one cast must go on a set of three beds. The annealing charge is divided into three parts—top, middle and bottom—with all the tops of the various charges going in one row of five beds, all the middles in another row, and the bottoms in the other. A sector is drawn off the beds, using magnets on an overhead crane, by taking one sheet off each pile in turn going down the rows of five.

Shearing.—All four sides are sheared true and square to each other to a $\pm^1/_{32}$in tolerance. This close tolerance is held by careful attention to the stops and shear blades and a strict sequence of shearing as follows : first shear to form a straight edge upon one side stopping from the throat area ; second shear to form a parallel to the first side, stopping from the first cut ; third shear to form two right angles, stopping from the throat area again ; fourth shear to complete the square, stopping from the third cut.

Drilling.—Two Asquiths 7ft o.d. 2 type radial drills are installed and equipped with a nest of locations for a half sector's worth of plates as received from shearing. These locations provide a base for a large drilling jig capable of locating fourteen holes at one setting.

Defray.—After a good deal of experimental work a special procedure has been devised to ensure that the surface finish of the plates should be to a very high standard. Using an overhead crane fitted with lifting magnets the plates are placed upon a table which is 30in above floor level. Then an electrically-operated sanding machine equipped with cloth based silicon carbide abrasive strip is passed across the surface of the plate in two directions. Next the plate is transferred to a second table for the deburring of all the holes and edges with Consolidated Pneumatic portable sanders.

D.R.N.S. Insulation.—After a sector has been "defrayed" and passed by inspection the plates are placed in a steam coil-heated soaking pit. After twenty-four hours the temperature will have risen to approximately 80 deg. Cent. The plates are taken out of the pit singly by an overhead gantry hoist fitted with magnets. Here again the operation has been made self-contained to ease the load on the overhead cranes. The plates are placed on the extended piston rods of four air cylinders attached to the platform of a recording Avery scale. The weight of each is recorded by the Inspection Department. Each sector contains forty-two or forty-three ¼in laminations with or without one ½in lamination. The weight can be controlled to ±252 lb on a total weight of 41,944 lb (18¾ tons) by varying the number of laminations at this point, i.e. ±½ per cent by weight.

After weighing, the plates are lowered by the air cylinders on to a chain conveyor taking them through an automatic spray booth. Here they are sprayed with an insulating coating of D.R.N.S.† on the top side. The heat of the plates dry the coating and as they pass out of the booth the D.R.N.S. is hardened by the direct heat from gas jets.

Magnet Sector Building

As there is a three-day building cycle three building beds are installed to allow for a continuous flow of work. The sectors are built in a horizontal position on a bed shaped to suit the final shape of the side of the sector. The shape of the sectors is influenced by the amount of crown in the half plates and the design also calls for added inter-lamination insulation around the throat area.

The first ½in plate is brought by overhead crane with magnets from the D.R.N.S. stockpile to a building bed. After careful inspection the plate is covered with insulating paper, narrow crown compensating paper is placed along the two edges and varnished, and the additional insulation is coated with resin placed around the throat area. The other plates, treated in the same way are stacked, finishing with ½in plate.

As each plate is assembled an electric resistance reading is taken with an Avo meter between each pair of adjacent plates. Fourteen insulated tie bolts are inserted and tightened to 20ft lb with a torque wrench. A separate shaped grid is positioned on top of the sector and 50 tons of weights

† D.R.N.S. is the name given to a patented insulating coating developed by Sankey's Bankfield works for application to electrical laminations. It is stated to be able to withstand temperatures up to 800 deg. Cent., to be no impediment to subsequent welding and to be unaffected by water or transformer oil.

distributed equally on the grid (Fig. 4).

Thickness checks of the sector are now taken. Thickness within the throat area must be within 12·710in and 12·860in, and along the back and edges it must not exceed 12·500in. An electric heater is placed within the throat to accelerate the curing of the resin overnight. Side plates are welded in position, 80 per cent of the welding is done at this stage. The weights and grid are removed, the tie bolts are tightened to 100ft lb torque and a rapid curing resin is applied to the nuts to lock them in position.

The bed is then raised upright by the 25-ton crane and the sector removed to a finish weld station at the extreme end of the building bay. Here the welds that were out of reach on the building bed are completed. The sector is then sprayed with grey paint and stands for seven days before machining.

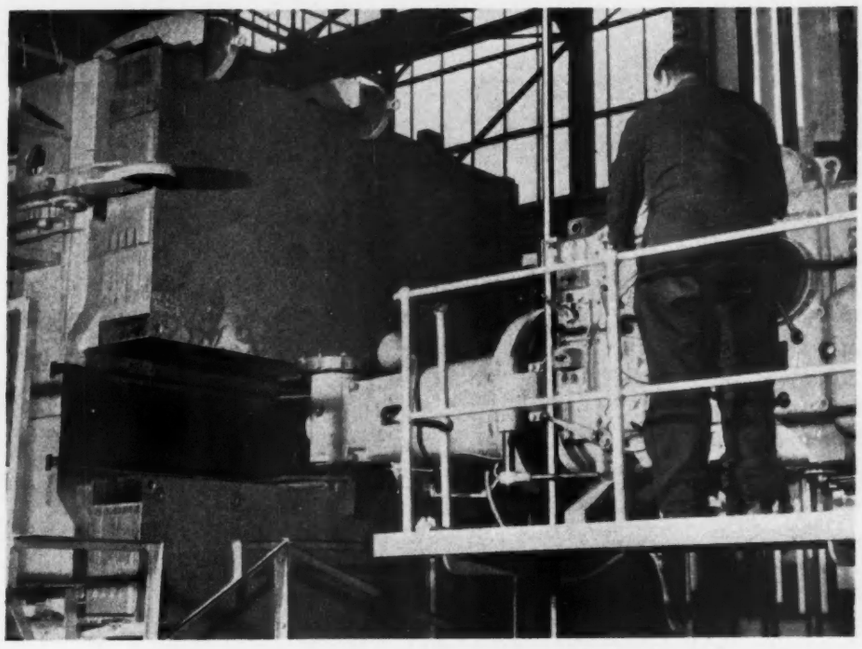


Fig. 5—Active area of throat of 20-ton magnet sector being finally machined to a tolerance of plus or minus 0·005in and a total tolerance of 0·004in in parallelism of the two faces

All subsequent operations are done with the sector vertical. The coil brackets and lifting lugs are fabricated as a sub-assembly where the rutile iron powder type of manual electrode is used. These electrodes have high metal recovery and fast deposition rates with a low hydrogen content weld metal deposit ; here also preforming of the plates is used to offset welding distortion. Side plate welds are made in two passes, using $^{5}/_{32}$in diameter Lincoln "Multiweld O.V." electrodes. Welding of the coil brackets to the magnet sector is done after the sector has been finally machined; this weld has to be full penetration which calls for double Vee preparation with a 95 deg. included angle.

Machining.—The following sequence of machining operations is carried out on the completely fabricated sector.

(1) The active section of the throat is machined to within 0·020in of finished size and to a tolerance of ±0·005in.

(2) The rear section of the throat is rough and finish machined to a final tolerance of ±0·015in.

(3) Taper (½ deg.) is machined on rear of sector for full height of 10ft 5in to a tolerance of 5 minutes on angle and +0·000in −0·020in thickness.

(4) Two 2½in by 1½in slots are rough and finish machined in throat to a tolerance of ±0·030in.

(5) The active faces of the throat are finish machined to a tolerance of ±0·0005in and total tolerance of 0·004in on parallelism of the two faces relative to one another (Fig. 5).

(6) Four pads are machined on the front of the sector to provide an accurate datum for fixing coil brackets.

The main points which called for a great amount of development work in establishing techniques are as follows. Each sector must age for at least eight days before any machining is attempted. No burrs between laminations are permitted as they would cause electrical short-circuiting. The minimum amount of clamping is employed, otherwise distortion takes place. Two fixed clamps only are used, all others being adjustable. For the final machining of the active face, the sector is held with scarcely any clamping whatsoever.

The temperature of the sector must be constant throughout its mass within 0·75 deg. Cent. It is found that any variation greater than this amount will cause movement in the extremity of the throat of up to 0·002in per 1 deg. Cent. An allowance of 0·00025in has to be made on the 23·000in throat gap dimension for every degree above or below 20 deg. Cent.

For all operations (except the 2·5in by 1·5in slot machining) 14in diameter face cutters are used, employing tungsten carbide blades. For rough machining the throat ten negative-rake blades are used, each blade being mounted progressively. For machining the half-degree taper on the rear of the sector, the same cutter is used. For final machining the throat seven positive-rake blades are used and are mounted in line. To ensure freedom from burrs, a freshly ground cutter is used for each sector. For the slot machining a Clarkson slot mill is used.

Coil Bracket Assembly.—After the sector has been completely machined the coil bracket assemblies (two) are jigged in position and sequence welded in place. The sector must then stand for at least twelve hours to allow the heat of welding to dissipate. It is then given a final coat of paint and taken by crane to the final inspection stand, where a complete dimensional check is made. A coat of strippable lacquer is given to the machined surfaces and the sector is completed ready for despatch to A.E.R.E., Harwell, by road transport. A completely enclosed holding fixture is provided for this journey.

Inspection.—Twelve inspectors are employed to ensure that all drawing and specification requirements are met. Final inspection of the magnet sector is carried out with the sector vertical. It is set up with the mean plane of the bottom throat face horizontal within 20 seconds of arc, the back taper faces being not more than 0·030in out of vertical, measured over the height of the sector.

A series of twelve readings are taken between the jaws of the throat on the 23·000in ±0·005in, after clinometer readings for flatness of 0·004in have been established. Thermometer readings (three) are taken at back of throat and again (six) at back of sector, ensuring the difference between individual readings in any group does not exceed 0·75 deg. Cent., and that the average of all readings in the three groups of three must not be more than 0·75 deg. Cent.

To emphasise the need for these very tight tolerances we append a short description of the installation procedure.

Alignment of the Magnet at Harwell

The geometric alignment of the magnet of the proton synchrotron presents unusual problems in surveying and metrology because of the high standard of accuracy which must be achieved over appreciable distances to maintain the plane of rotation during commencement and completion of bursts of protons. This accuracy can be affected by sinking or tilting of the magnet foundation monolith, or by distortion of the monolith.

In addition, it is necessary to locate with accuracy not only the angular and radial position of each sector, but the height and tilt of each relative to any other. Furthermore, once the magnet is set up and the coils and vacuum chambers installed, no realignment of the magnets is contemplated unless there is a significant loss of beam power.

The first precise survey which will be carried out as soon as suitable conditions exist in the magnet room, will start from construction survey marks. Especially designed instrument stands will enable a precision theodolite or "Invar" tape measuring gear to be set up vertically over the marks by the use of optical plummets. The surveyors will record the measured lengths and angles and extract the data required by the National Physical Laboratory who will, using a "DEUCE" computor, establish the corrections necessary.

In the first survey the position of the sole plates to which the magnet sectors are bolted will be surveyed. The method of establishing the true position of each of the primary datum points will be first used to position, in the floor pockets, datum plates with a fiduciary bolt which will then be grouted in position above the construction mark steel plates.

The second survey will determine the true position of the fiduciary bolt, but the correction will be applied to position correctly an adjustable datum socket bolted to each datum plate. The adjustable datum sockets have a conical seating to receive a partial sphere with a concentric graticule which will be viewed by an optical plummet. When the adjustable datum socket has been correctly set the sphere will be removed and a suitable

cover plate placed in position to protect the datum socket.

It is anticipated that each primary datum point will be established to within 0·005in of its true plan position.

During the foregoing process the relative heights of all the primary data will be established by placing in the datum socket an Invar staff with a spherical end and determining the differences in level by means of a precision "dumpy" level. Forty-four observations will be made on the twenty-four primary data and the results processed by "DEUCE" at the N.P.L. to yield corrected values of the height differences with reference to one point which has been selected as a datum.

After the second survey, further surveys will be carried out as required to check the stability of the monolith. In these surveys the graticule sphere will be used during the measurement and correction phases.

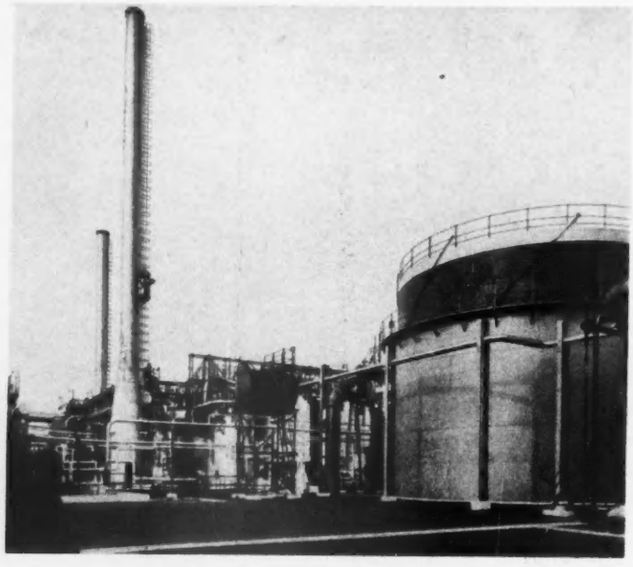
The dimensional stability of the monolith may be affected by shrinkage of the concrete during curing, which is a long process in massive structures ; by temperature changes, and by deferred creep caused by the stresses imposed by the very substantial loads, due to the weight of the magnets and the weight of the roof and thick earth cover.

To assist in assessing these effects, moisture gauges and thermocouples are being installed at varying depths in the concrete of the monolith, and strain gauges are being installed in the cavities of the monolith. A remote indicating system with twenty resistance thermometers, which can be read at one station to an accuracy of 0·2 deg. Cent. will be installed. Immediately prior to magnet sector installation, account will be taken of these effects when determining the correction to be applied to the adjustable data at the primary datum points.

The project team have used on a consultancy basis the services of the National Physical Laboratory and Hilger and Watts, Ltd., for determining the surveying processes and techniques. The consulting engineers, Messrs. Merz and McLellan, and the Building Research Station, have been consulted on the likely behaviour of the monolith and the latter is installing and will take measurements on the moisture and strain gauges and thermocouples.

Romford Gas Reforming Plant

The gas reforming plant of the North Thames Gas Board was recently officially opened at the Romford Gas Works. This plant is fed with refinery gas from Shell Haven and Coryton, and it will also use methane imported in liquid form from the United States. The original productive capacity of this works was 5,000,000 cubic feet of gas a day; with the new reforming plant and oil gasification plant its capacity has been increased tenfold. A paper describing the plant was read at the summer meeting of the Institution of Gas Engineers by Dr. J. Burns, the chief engineer of the North Thames Gas Board, and Mr. E. R. Stewart, the station engineer. We reproduce abstracts from this paper.



THE North Thames Gas Board, in its position remote from the coalfields and dependent upon supplies of coal from the North East Coast, recognised the ill-effect that successive coal price increases were having on the economics of gas manufacture and sought to devise ways and means of checking its rising costs. The Board had much previous experience in the conversion of oil to gas, and investigations into the possibilities of using raw materials from two big oil refineries at Shell Haven and Coryton made it apparent that the most suitable raw material on offer was refinery gas in quantities worthy of attention. There were many factors to consider on the best method of using this new raw material. It was clear that the gas would have to be transported to the nearest suitable point in the Board's grid system at Romford, some 17 miles away. Then came the decision as to whether refinery gas should be converted into town gas on site at the refineries, or whether it should be transported in its rich form to the grid for reforming. The factors affecting the decision to transport the gas from the refineries to the grid in its rich form are worthy of comment. In the first place, the costs of transmission of gas of high calorific value are lower ; secondly, the acceptance of high calorific value gas allows of its use for different purposes, which gives a degree of flexibility with more overall economic operation. Thus, it can be used :

(i) For direct reforming to 500 B.Th.U. per cubic foot.

(ii) For cold enrichment of blue water gas to displace gas oil, where it is economic to do so, and

(iii) To exert some control on coke availability by influencing coke consumption in carburetted water gas manufacture.

The benefit of flexibility in meeting the varying load was a potent factor in the decision to carry rich gas to the grid system before treatment. Additionally, the Board had in mind the possibility of importing liquid methane at Canvey ; besides, treatment of methane at the grid would be advantageous. The decision to transport high calorific value gas from the refineries carried with it certain requirements in respect of mains and gas quality. The gas was available at high pressure and it was obviously of advantage to use this pressure for transmission and for storage in the main. This pressure required a steel main, and in order to cater for future possibilities, it was decided to install a 24in diameter main tested hydraulically to withstand a pressure of 400 lb per square inch.

The high-pressure steel main in turn imposed a very strict specification for the hydrogen sulphide content of the gas, and agreement was reached that this should be not more than 0·5 p.p.m., with the organic sulphur content of not more than 5gr per 100 cubic feet; and that the water dew-point should not be above 28 deg. Fah. at the pressure at which refinery gas entered the main. The amount of gas involved in the first place was 25,000,000 therms per annum, rising to 37,500,000 therms per annum in the second year, with further rises foreseen for the future.

Surplus refinery gas can vary quite widely in composition, dependent upon the type of crude oil under treatment or the particular refinery process supplying the gas, and provision was made in the agreement for the Board to accept gas that could vary in calorific value between 900 and 2300 B.Th.U. per cubic foot. It was recognised that any rapid change in the calorific value of the refinery gas could affect the efficient operation of the reforming unit and, in practice, maximum possible notice is given of any impending alteration in the composition of the refinery gas. In this connection, of course, the high packing capacity of the 24in high-pressure pipeline is a very important factor ; this same pipeline acts as a reservoir for gas to tide over incidental shut-downs that might last up to five hours. It was found, in practice, that the refinery gas supply may be subdivided into three main types, characterised by calorific value of about 1000, 1500 and 2000 B.Th.U. per cubic foot.

Knowledge of the constitution of the gas coming into the plant is vital to its successful operation, and there is of necessity very close collaboration between gas analysis and plant control. The carbon : hydrogen ratio provides an indication of the proportion of process steam to be admitted with the process refinery gas to achieve efficient reforming, while "carbon volume"/"volume" of

refinery gas is a more convenient method of expressing the carbon : hydrogen ratio for the purpose of practical plant control. Theoretically, 1 " volume " of steam at standard temperature and pressure will react with 1 " volume " of gaseous carbon at s.t.p. to produce carbon monoxide and hydrogen.

Metering and Instrumentation at the Refinery

Accurate control of the amount of raw materials is essential to the operation of the supply agreement as well as to the process of reforming, and the Shell Refinery Company at the outlet of the refinery at Shell Haven paid much attention to the measuring and general control equipment.

Measurement of the high-pressure gas at the refinery is carried out in an orifice plate meter, with transmission to a recorder for continuous registration. The calorific value of the refinery gas is continuously recorded by a Reineke calorimeter on a strip chart, with a second calorimeter to act as a check to maintain the standard of measurement. These instruments operate successfully over a range and up to 2100 B.Th.U. per cubic foot.

Hydrogen sulphide is recorded on a Rubicon analyser, which registers the concentrations hourly ; if the concentration increases, the period alters. The specific gravity is continuously recorded by a Sigma instrument with a range of 0·5 to 1·4, and hydrocarbon dewpoints and water dewpoints are recorded.

The Reforming Plant

The Gas-Making Units.—The plant selected for the duty at Romford was of the " Onia-Gegi " type designed and constructed by Humphreys and Glasgow, Ltd.; it consists essentially of four identical units,

The preheater is a mild steel refractory-lined vertical cylindrical vessel of 12ft i.d. At the foot of the vessel is the combustion chamber equipped with the primary burner (of Urquhart design) and a small pilot burner with an automatic flame-failure shut-down device. A set of refractory arches across the preheater supports a section of chequer brick packing, on top of which a layer of sole bricks carries the first catalyst bed of 12in depth.

The reactor is of mild steel construction lined with refractories, and is of 17ft i.d. The inlet at the top, leading from the preheater, is designed to promote even gas distribution across the catalyst bed, which is a layer 18in deep, supported by sole bricks on arches across the vessel. There is a total of 17½ tons of catalyst in each of the four units, one-quarter of this being in the preheater and three-quarters in the reactor. The secondary burner is situated at the top of the vessel.

The waste-heat boiler takes both the " make " and the " blow " gases, and is of the horizontal fire-tube type, designed for a working pressure of 300 lb per square inch. On the waste-heat boiler outlet is a vent stack valve that opens to atmosphere only in the event of a plant cut-out, the main stack valve, and also the outlet connection into the washbox.

The washbox is of conventional design and has a flat base.

Waste gases pass out of the main stack valve during the heating phase and enter a tubular heat interchanger before continuing to atmosphere via a single common stack 125ft high. There are two heat interchangers, each associated with a pair of gas-making units, and they serve to preheat the air blast to their respective units to temperatures of about 130 deg. Cent. The arrangement of the plant vessels is clearly shown in the phase diagrams in the section explaining the operational cycle. (This reforming plant is illustrated in Fig. 1.)

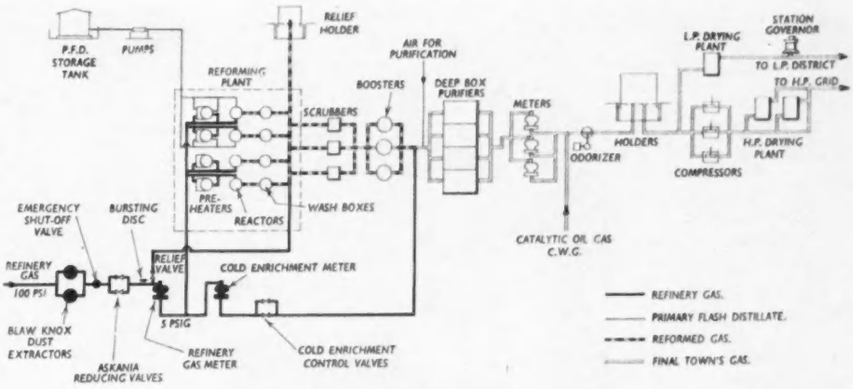


Fig. 2—Gas flow diagram

The Ancillary Plant.—The gas outlet main from the four washboxes leads to three washer-scrubbers packed with wooden grids, where the gas is cooled by direct contact with water. From the inlet to the washer-scrubbers is a connection to a column-guided hot gas relief holder of 50,000 cubic feet capacity. Cooled gas passes from the scrubbers to the three boosters, and automatic control of the booster speed is provided for and is actuated by the rising or falling of the relief holder, through a form of mechanical linkage to the turbine governors. If the holder falls to a predetermined low level, the steam supply to the booster turbines is completely shut off, while in the event of the holder reaching an unduly high level the gas-making units are automatically shut down.

Refinery gas for cold enrichment is admitted at the booster outlet, and the final gas then passes to the deep box purifiers (after the admission of controlled quantities of purification air) and thence to the three Holmes Connersville meters and into the works holders.

Fig. 2 shows the plant layout in diagrammatic form.

The Refinery Gas System.—The 24in steel pipeline enters the Romford gas works at the south-eastern boundary and is there reduced to 16in diameter. At this point, two Blaw-Knox cleaners, which operate in parallel, remove any entrained dust. The 16in steel main passes to the reforming plant, where the refinery gas supply pressure is controlled by hydraulically operated " Askania " reducing valves to a pressure of 5 lb per square inch. Immediately before the " Askania " reducing valves, a Bryan Donkin automatic shut-off valve is provided in the main line, and this is set to close at 9 lb per square inch in the event of a failure of the " Askania " valves. A 3in relief valve is provided on the downstream side of the " Askania " valves, set at 9 lb per square inch to release to the relief holder any gas in excess of this pressure, and as a further precaution a bursting disc has been provided before the Connersville meter.

The volume of incoming refinery gas is registered on a Holmes Connersville meter, which is fitted with a pressure, volume, temperature and time recorder. On the outlet of this meter, the refinery gas pipeline divides into two streams, one to the reforming plant for processing, the other to a second, smaller

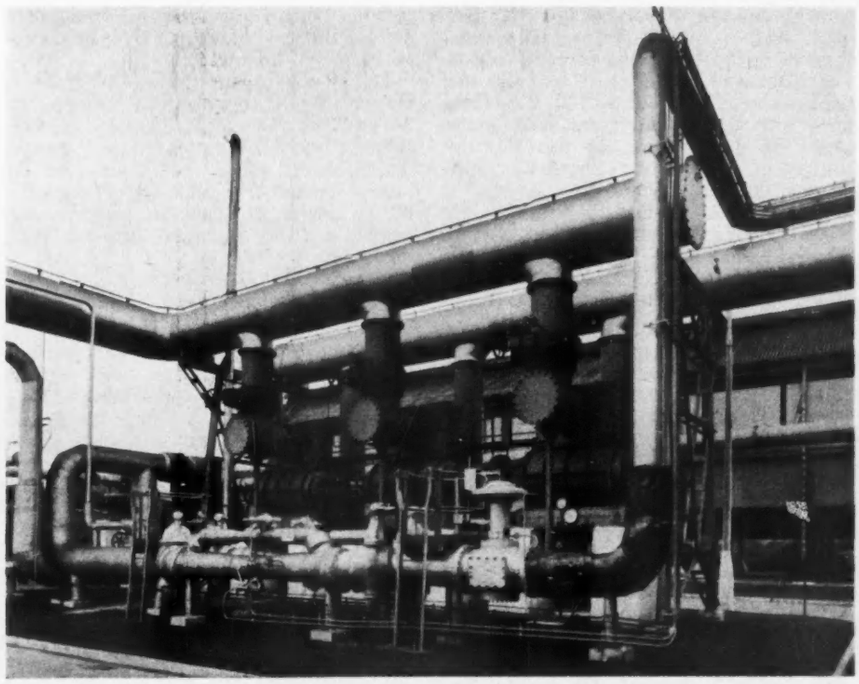


Fig. 1—Refinery gas reforming plant with the meters for incoming refinery gas and outgoing reformed gas in the foreground

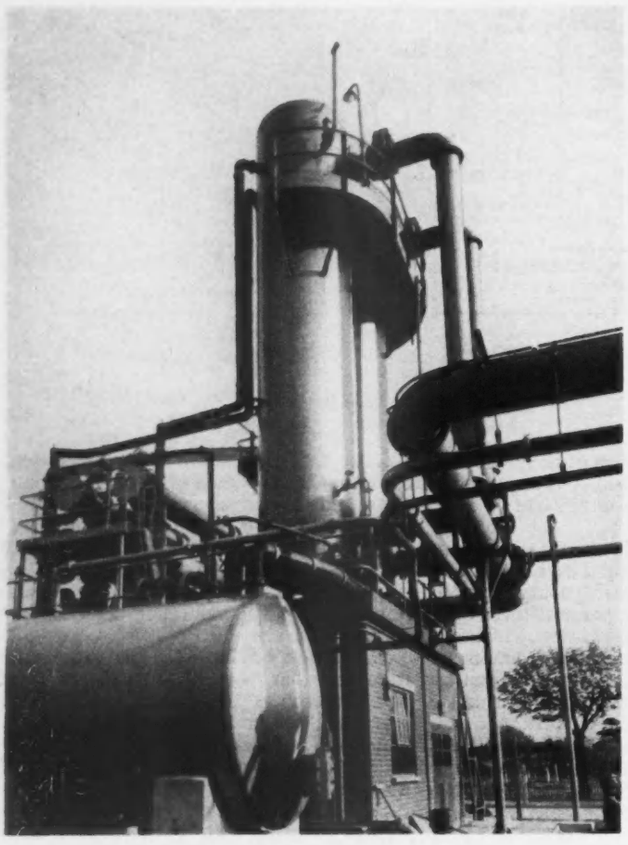


Fig. 3—High-pressure gas drying plant

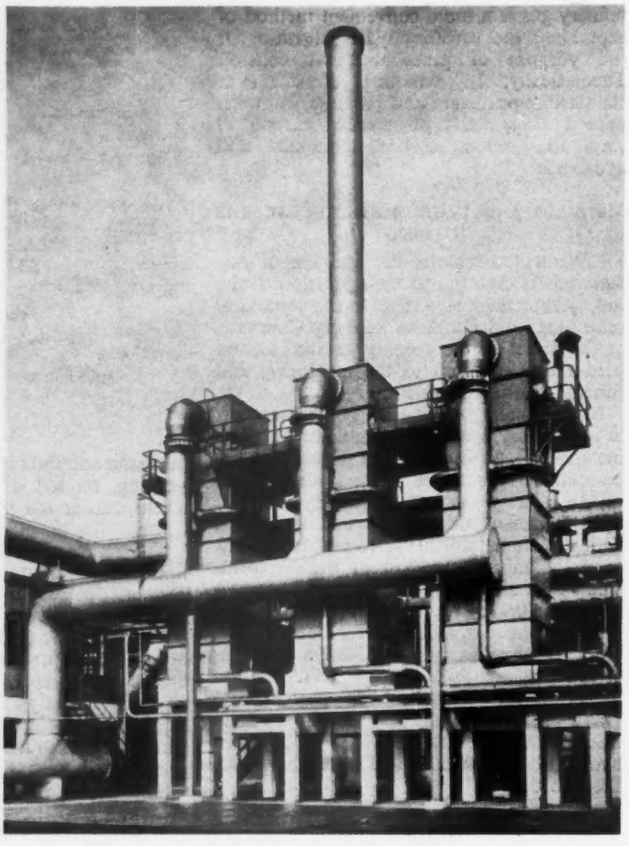


Fig. 4—Gas cooling plant

Connersville meter, which registers the volume of gas for cold enrichment. The volume passing through the cold enrichment gas meter is controlled by the Kent "Sigma" system to maintain a final gas calorific value of 500 B.Th.U. per cubic foot.

The Steam System.—The steam system has been designed so as to make the plant self-supporting in steam in respect of its process requirements and for air blowing and gas boosting. Steam generated in the waste-heat boilers at 300 lb per square inch (superheated to 570 deg. Fah.) supplies the blower and booster turbines, which pass out into the medium-pressure system at 20 lb per square inch pressure. Low-pressure steam for process use, at 15 lb per square inch, is supplied from the high and medium-pressure system through "Arca" reducing valves, and also from the boiler feed pump exhaust steam. A steam accumulator in the medium-pressure system absorbs cyclic fluctuations. High-pressure steam surplus to plant requirements passes into the works steam system at 120 lb per square inch.

The plant is fully instrumented although there is no final operational control by the instruments themselves, but the complete automatic operation of valves and the automatic control of safe operation allows the plant to run with minimum labour. All plant flow control valves can be adjusted by hydraulic transmitters from the control room, and all line-pressure and flow-meter readings are transmitted back to the control room by pneumatic instruments. A central instrument panel contains slave indicators showing the calorific values of the refinery gas, the lean gas and the final gas.

Oxide Purification

Although the specification for the refinery gas provides for only 0·5 p.p.m. of sulphuretted hydrogen and an organic sulphur content not exceeding 5 gr per 100 cubic feet. It was recognised that this organic sulphur would be converted to sulphuretted hydrogen in the reforming process, with the production of hydrogen sulphide just very slightly in excess of the statutory limit.

It was decided to install a simple form of oxide purifiers, for it was recognised that, apart from pressure requirements, the oxide would require to be changed not more than once in four or five years. The boxes supplied by the Oxley Engineering Company, Ltd., consist of four deep welded mild steel boxes, each 32ft by 32ft by 12ft, each being fitted with a single cover and holding two layers of oxide, each has provision for convergent or divergent gas flow. Quite apart from their function in removing the minute traces of sulphuretted hydrogen, the boxes have proved efficient filters for the removal of very finely divided carbon.

The Reforming Operation

The reactions between refinery gas hydrocarbons and steam in the presence of a nickel catalyst at temperatures of 650 deg. to 850 deg. Cent. yield a mixture of carbon monoxide, carbon dioxide and hydrogen when reforming is carried to completion. The relative proportions of these products depend upon the following factors :

(1) The composition and quality of the refinery gas.

(2) The temperature of the reaction and nature of the catalyst.

(3) The amount of excess steam employed.

The maximum possible gaseous thermal yield will be obtained when reforming is complete, and it is possible to obtain from each therm of refinery gas treated with steam up to 1·24 therm of reformed "lean" gas with a calorific value up to 300 B.Th.U. per cubic foot. In practice, however, it is not always economic to operate to completion, and the reformed gas will contain methane and have a calorific value between 310 and 320 B.Th.U. per cubic foot. Other side reactions will cause further deviation from ideal reforming, with, possibly, the deposition of small quantities of carbon. If, however, plant temperatures are kept within prescribed limits, the deposition of carbon, with consequent reduction of gaseous output, is found to be too small to be of serious concern.

During the heating phase, the nickel in the catalyst is progressively oxidised to NiO and possibly Ni_2O_3. These oxides are fully reduced again during the early part of the reforming phase, and control of the rate of oxidation of the catalyst by control of the amount of excess air used for combustion is a very important feature of plant operation.

The Operational Cycle

The cycle at present being employed is of 4·83 minutes duration, and the following description of the different phases of the cycle should be read in conjunction with the phase diagrams shown in Fig. 6 (*a*) and (*b*).

Heating Phase.—After the primary burner comes into operation, the main stack valve opens ; this is followed immediately by the introduction of the secondary burner. The air blast, preheated to about 130 deg. Cent., ignites with the refinery gas at the burner, and the resultant hot combustion products together with the requisite amount of excess air pass from the combustion chamber up through the preheater. After giving up heat to the chequer bricks and first catalyst bed, these gases then pass into the reactor where they are augmented by the secondary burner. After raising the temperatures of

Fig. 5—The control room at Romford gas works

the second catalyst bed, the waste products pass through the waste-heat boiler, via the main stack valve, to the heat interchanger to preheat the incoming blast, and thence via the common stack, to atmosphere.

Make Purge.—On completion of the heating phase, the primary and secondary burners are shut off, and the process steam valve opens. Steam passes through the vessels in the same direction as the heating gases and sweeps the waste gases forward to the stack.

Reforming Phase.—The reforming phase commences with the opening of the process gas valve and the closing of the main stack valve. The process refinery gas, mixed intimately with the steam, is then preheated by passage through the chequer bricks. Some thermal reforming takes place at this stage, but the greater proportion of the total reforming is achieved in the first catalyst bed. Final reforming is completed in the reactor. The resultant lean gas passes through the waste-heat boiler, into the washbox and thence to the ancillary plant. A short time before the end of this phase, the process gas valve is closed, leaving the steam to purge the residual lean gas forward.

Blow Purge.—The process steam valve closes and the primary burner opens simultaneously. The combustion gases then assist in the purging of the vessels for a short period before the main stack valve opens, and the cycle commences once more.

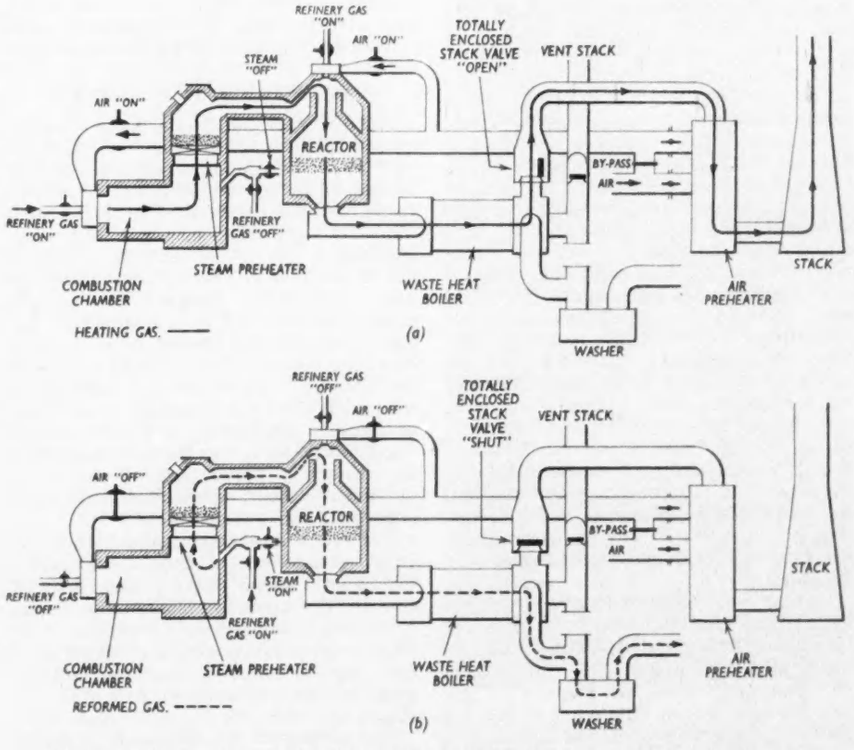


Fig. 6—(*a*) Diagram of the heating phase and (*b*) the reforming phase of the gas reforming cycle at Romford

It should be pointed out that, owing to the variations in the quality and quantity of the feedstock employed, adjustments to the cycle are required more frequently than on a carburetted water gas plant if optimum efficiency is to be achieved. This does not lead to any undue difficulty, however, because there are only five levers on the automatic operator and a special modification permits the most frequent adjustment to be made very simply and quickly.

A typical cycle, as used on middle-range refinery gas, is set out in the table below.

Typical Cycle of Operations

Valve operation	Percentage of cycle		Duration	
	Open	Shut	Per cent	Sec.
1	2	3	4	5
Stack	0	37	37	107
Primary burner ...	96	33	37	107
Secondary burner	2	33	31	90
Process gas	37	92	55	160
Process steam ...	33	96	63	183

Practical Aspects of Plant Control

Refinery gas supplied to the reforming plant is used in approximately the following proportions :

	Per cent
(*A*) Process gas for reforming	40
(*B*) Burner gas for heating	10
(*C*) Cold enrichment	50

These proportions will, of course, vary according to the quality of the refinery gas and the rate of gas making, and must be in correct adjustment under any given set of operating conditions if the maximum possible plant efficiency is to be maintained. [The paper goes on to deal with the control of the plant, its operational results and performance, and concludes with the following paragraphs.]

The plant at Romford has already shown a very high output of gas and great flexibility, and it is intended to continue with work on additional feedstocks. Work is in prospect on the use of primary flash distillate as a feedstock to one unit, while refinery gas would be used on the remainder. Work is also in prospect on the use of primary flash distillate in place of refinery gas for heating purposes, to allow of such operation if economic considerations make it advantageous. The wide range of gas composition that can be achieved on this plant makes the Board's present studies of the possibility of removing carbon monoxide, without subsequent removal of the carbon dioxide produced, particularly interesting.

Since May 5, 1958, when the reforming plant commenced operation, gas production has proceeded smoothly. The units have worked throughout in a reliable and efficient manner. The flexibility of operation has been a satisfactory feature, and the quality of the gas is particularly attractive in that it contains no sulphur.

Merchant Ships Lost.—Lloyd's Register of Shipping casualty returns for the quarter ended September 30, 1958, show that of the world total of thirty-one ships of 57,683 tons gross lost consequent upon casualty, one ship of 162 tons was owned in Great Britain and Northern Ireland. The corresponding figures for ships broken up, &c., were ninety-one ships of 292,059 tons and forty-three ships of 107,473 tons respectively.

Aluminium in Building.—The Aluminium Development Association has arranged a Symposium on Aluminium in Building to be held on July 9 and 10 at the Royal Institute of British Architects, 66, Portland Place, London, W.1. There will be three sessions during which fourteen papers will be presented on "Aluminium as a Building Material," "Aluminium Curtain Walling," and "Aluminium Building Applications."

Mainly Metallurgy

by T. Henry Turner, M.I.Mech.E. M.I.Loco.E. A.R.Ae.S. F.I.M.

Annual Review of Professional Metallurgy

DURING recent weeks the Professional Institutions have been holding their annual general meetings and hearing their Presidential Addresses ; certain Research Associations have similarly reported on the work they have done and the programmes they now have in hand, and they have invited their members to " Open Days." One may obtain a useful answer to the question as to where an engineer or other user of metals should turn for data about metals and alloys by recalling these functions. Doing so helps one to co-ordinate their activities and to see how these more important and widely known associations of professional metallurgists in this country link together to cover the whole field.

Church House, Westminster, was the venue for the annual general meetings of both the Iron and Steel Institute and the Institute of Metals ; the former on May 6, and the latter on April 14. Many of the more scientifically minded and professionally qualified members of these two Institutes met again, on May 12, in the Park Lane Hotel, Piccadilly, London, at the annual general meeting of the Institution of Metallurgists. Then followed the annual general meeting of the Institution of Mining and Metallurgy on May 21, at the Geological Society, Burlington House, Piccadilly.

Following the same order as above, these four organisations elected and installed the following four gentlemen as their new Presidents, William Barr, O.B.E., G. L. Bailey, C.B.E., Professor A. J. Murphy and Mr. J. W. Watson. They now sit in the seats which were occupied during last session by their predecessors Charles R. Wheeler, C.B.E., The Lord Tedder, G.C.B., D.C.L., LL.D., Mr. W. E. Ballard and Mr. J. B. Dennison.

The work of the Institute of British Foundrymen, the Institute of Metal Finishing, and the Institute of Physics are naturally also of interest to metallurgists ; indeed the Presidents of the first two, namely, Mr. A. E. Peace and Dr. T. P. Hoar are both well-known metallurgists.

Then one should also recall that the Corrosion Group of the Society of Chemical Industry elected Mr. Leslie Kenworthy as its new Chairman, at its annual general meeting which was held in the headquarters of the Society, at 14, Belgrave Square, London. Although not an independent society in its own right its membership has already risen to 550 since its relatively recent formation in 1951, and engineers and other users of metals have been much helped by it.

Metallurgical Research Associations

The British Non-Ferrous Metals Research Association and the British Cast Iron Research Association both arranged " Open Days " during the month of May. On the 13th of the month the B.N.F.M.R.A. held its annual meeting and luncheon in the Savoy Hotel, London, and invited its members to visit its laboratories at 81–91, Euston Street, London, N.W.1, where the accommodation has been increased notably, for the third time since its virtual destruction during the war, and is now at last suitable in all respects for its work.

The British Cast Iron Research Association formally opened its new Foundry Atmospheres Building, in its laboratories at Alvechurch, near Birmingham, on the 28th of the month. Dr. J. G. Pearce, C.B.E., its former Director who was asked to perform the ceremony, always recognised the need for a clean working atmosphere in the foundry but the Clean Air Act has added urgency to this phase of the work of the B.C.I.R.A.

The British Iron and Steel Research Association's annual report for 1958 also appeared during this period, in the same informative booklet form as in previous years. It announces the completion of a new block at the Battersea Laboratories and it sets out in detail the Association's widespread activities, complex structure of committees and numerous specialised laboratories.

Non-Ferrous Metals Research Facilities

In the first decade of this century there was in this country a multitude of small brass foundries, rolling mills, wire drawers, tube makers, electroplaters and so on, many of them located in the Birmingham area. Their owners believed in their trade secrets and were faithful to their traditional skills. But they had hardly heard of the word " research " ; indeed their few pioneering works chemists and works metallurgists were strictly forbidden to co-operate with one another for fear that they should pass on to their competitors what should be reserved for their employers.

The dire necessities of 1914–18 which required unexpected mass production and brought in its train unprecedented destruction, led to the first co-operative research in Birmingham. Although there were at the end of 1918 only two technical assistants and a girl typist, working under the honorary direction of the local Professor of Metallurgy, a start had been made and co-operation in research had commenced. Expansion soon followed on the formation of the Department of Scientific and Industrial Research, even though modestly at first, and so the British Non-Ferrous Metals Research Association was formed nearly forty years ago. To-day well over 600 firms are members of the " B.N.F." as it is now usually called, and its annual income from industrial contributions and Government grants amounts to some £200,000 per annum, and 20–30 per cent of its industrial income derives from Commonwealth countries outside the United Kingdom.

At first it had no laboratories and many of its earlier research workers carried out their experiments in the Metallurgical Department of the University of Birmingham. In those early days the pioneers of co-operative research in metals had to face the problem of where to locate the laboratories, which they knew would be required. Should they be built near to the metal producers or to the metal users ? And in either case which group of metals or users should be favoured by their proximity ? Finally it was agreed that the most uniform accessibility to makers, users, and to the interested Government and its Service Departments would be found in or near to London, and so in 1930 the B.N.F.M.R.A. established its first laboratories at 81–91, Euston Street, London, N.W.1.

Members now make about 1000 visits a year to these premises for discussions of technical problems, for research planning committee meetings, to use the very excellent technical library or to observe the work in progress, and this is not surprising for non-ferrous metals are used in essential equipment in all sorts of engineering.

The work of the Association is divided between three departments : Research, Liaison and Technical Services, Information and Library. The Research Department is by far the largest of these and currently has over forty major research projects in progress.

There has long been an appreciation of the need for a Liaison and Technical Service and this department has the second largest budget, absorbing about a fifth of the total expenditure. The present Director of the Association, G. L. Bailey, served in this department for many years, and he now holds the double distinction of being the President of the Institute of Metals and a Past-President of the Institution of Metallurgists. The internal organisation of the Research Department is based on functions rather than materials and there are seven sections, namely : (1) Melting and Casting ; (2) General Metallurgy ; (3) Mechanical Testing ; (4) Corrosion ; (5) Metal Finishing ; (6) Physics ; (7) Chemistry ; each gives service to the others when necessary.

Destruction–Rebuilding–Expansion

When Sir Alexander Fleck, K.B.E., F.R.S., opened the newly-finished laboratory block, on May 13, 1959, by unveiling a plaque that was especially novel in that it was a memorial engraved upon the metal titanium, several things of significance to engineers became apparent. This is the third expansion of the B.N.F.M.R.A. laboratories since the block which they occupied in 1930 was practically destroyed during the war, and the Association now possesses for the first time accommodation suitable in all aspects for its work. The choice of titanium for the memorial plaque, a metal quite unknown to practical engineering at the time when the B.N.F.M.R.A. was founded, symbolises the increasing importance of the newer non-ferrous metals, especially in aeronautical and nuclear energy applications.

The block now completed adds another 12,500 square feet of floor space, raising the total to about 53,000 square feet. It contains new corrosion laboratories, a large new metal finishing shop, extensions to the physics laboratories and the foundry. It has also permitted a welcome improvement of the main entrance and a Council Room and offices for the senior staff.

The exterior of the laboratory buildings, as may be seen in one of the illustrations, seen from the far side of Euston Street now

appears for the first time as a businesslike whole with a 180ft frontage. The new block on the right of the entrance has been built in keeping with the wing built in 1938 and the laboratories extend behind in three blocks. No money has been spent on architectural embellishments and one could wish that someone would use an electronic computer to prove how much nicer it is to work in handsome buildings. In view of what one may see elsewhere can we now afford the absence of fine looking exteriors to our utilitarian buildings ?

Exterior of the newly extended B.N.F.M.R.A. laboratories in Euston Street, London. They have a frontage of 180ft

The Non-Ferrous Metals Industry may justly feel proud of the measure of real co-operation which has been achieved among the firms concerned as symbolised in these laboratories. Engineers in doubt about the properties of non-ferrous metals may now be advised to ask " The B.N.F."

Commonwealth Production

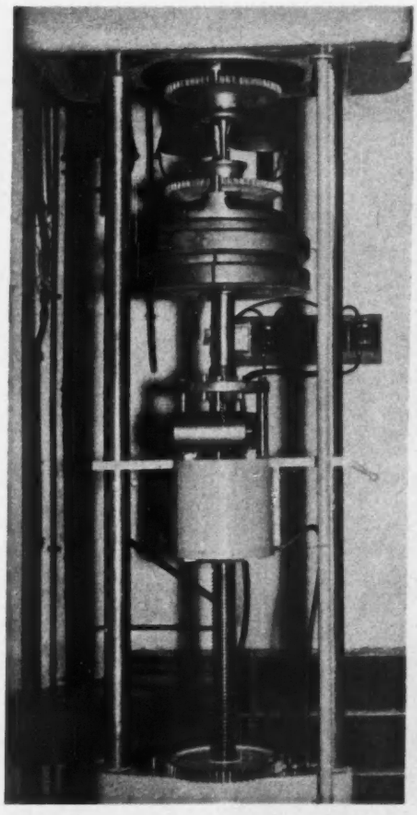
In his Address at the opening of the new laboratories, Sir Alexander Fleck quoted some figures which show that there have been recently several striking increases in the production of non-ferrous metals in the Commonwealth. In Australia, between 1950 and 1957, copper production trebled and consumption doubled to 40,000 short tons ; lead production went up from 230,000 to 350,000 tons ; zinc from 186,000 to 274,000 tons ; and aluminium from 0 to 12,000 tons. Canada has a similar story ; copper production rose from 264,000 to 360,000 tons ; zinc from 313,000 to 410,000 tons ; aluminium from 397,000 to 557,000 tons ; and nickel from 124,000 to 188,000 tons. This was all between 1950 and 1957. Malaya's tin industry is twice the size of that of any other country. It is less known that its bauxite production rose from 0 to 365,000 tons between 1951 and 1957. Even that effort is eclipsed by Jamaica's. In those six years Jamaica increased its output from 0 to over 5,000,000 tons per annum, thus becoming by far the largest producer in the world.

Turning to Africa Sir Alexander mentioned that Northern Rhodesia, the third largest producer of copper, raised its output from 328,000 to 480,000 tons between 1950 and 1957.

The new moulding bay at B.N.F.M.R.A., built to relieve congestion in the melting and casting shop. Contains plant for sand moulding, the CO_2 process and shell moulding

Corrosion as a Design Problem

Dr. S. G. Clarke, who has just completed his two years term of office as chairman of the " Corrosion Group " of the Society of Chemical Industry, gave his Chairman's Address at the end of the Annual General Meeting on May 6. He chose as his title " Corrosion as a Design Problem," and, basing his remarks on his own exceptional experience of how things corrode in all parts of the world, quoted specific examples. He is the head of a small team of corrosion experts, who are employed continuously by the Ministry of Supply, more especially in the Armament Research and Development Establishment. Examples of design choices being influenced by corrosion which he cited were brass and anodised aluminium buttons for uniforms, brass and steel cartridge cases, stress corrosion and underground corrosion. He summed up by underlining the need for adequately specifying, at the very outset, with regard to the corrosion influences.



10-ton direct stressing " Vibraphore " fatigue machine in use at the B.N.F.M. research laboratories for comparing the performance of light alloys and steels in connection with transport application

Since its formation in 1951, the " Corrosion Group " has grown steadily and now almost amounts to a new technical society. It has been and still is dependent upon the excellent secretariat and lecture room facilities provided by its parent society in the well-equipped premises at 14, Belgrave Square. In it the Institute of Metals and the Society of Chemical Industry are near neighbours.

Mr. Leslie Kenworthy, of the Admiralty Materials Laboratory, was elected to be the next chairman of the Corrosion Group, whose membership now amounts to 550. During the session just completed it held thirteen meetings. Two lecturers from abroad were welcome visitors : Professor Smialowski from Warsaw and Professor Feitknecht from Bern. Both gave first-hand accounts of the progress of research in their laboratories.

The Group has friendly contact with many overseas bodies. In May, 1958, Dr. E. C. Potter and Mr. J. B. Cotton represented the Group at the U.S.S.R. Corrosion Congress in Moscow. Dr. T. P. Hoar is the British correspondent to the Inter-Society Corrosion Committee of North America, and the Group also keeps in touch with the European Federation of Corrosion, although not yet a member of it.

As now planned by the Group, the most important occasion in its next session will be a Symposium on the Corrosion Problems of the Petroleum Industry, to be held in London next November, jointly with the Chemical Engineering Group and the Institute of Petroleum. Preparations are also being made for a Symposium on Corrosion Prevention in the Gas Industry, to be held in Birmingham in 1960, in collaboration with the Birmingham College of Technology.

Nuclear Reactors for Marine Propulsion

No. III—(*Continued from page 796, May 22*)

Recently we published an Admiralty announcement that a number of firms and consortia had proposed designs for nuclear reactors for ships. The merits of these designs are to be assessed by a technical sub-committee of the Civil Lord's Committee. We have secured particulars of some of these designs.

A CLOSED-CYCLE boiling-water reactor forms the basis of the 50,000 s.h.p. marine propulsion system proposed by the consortium consisting of Mitchell Engineering, Ltd., The Fairfield Shipbuilding and Engineering Company, Ltd., and Combustion Engineering Incorporated.

At normal full power conditions, the nuclear plant is designed to produce steam for two sets of 25,000 s.h.p. engines and for all power plant and ship's auxiliaries. The proposed system uses a closed-cycle boiling-water reactor with four heat exchanging loops, each loop comprising a primary separator, a condenser heat exchanger, a sub-cooler, a circulating pump and associated pipework and valves.

The cut-away model of the reactor illustrated in Fig. 15 shows the reactor core and pressure vessel in the centre with the control rod actuators above. The main plant items disposed around the reactor vessel and enclosed in the containment compartment are the four condenser heat exchangers in the dome of the compartment (Fig. 15) and, at successive levels below that, the primary separators, the sub-coolers and the circulating pumps.

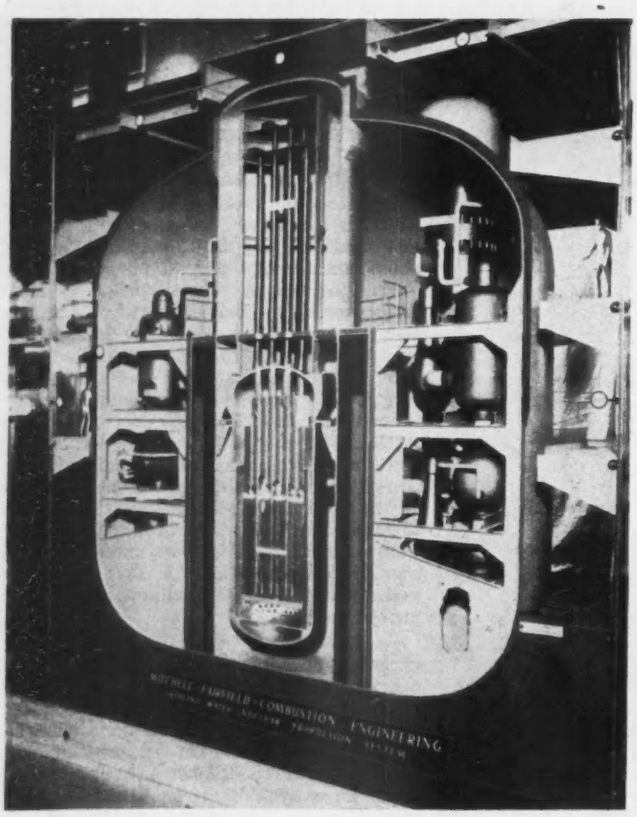
The main particulars of the system are tabulated alongside. Although the reactor is rated at 175MW the reactor thermal output at full power would be 156MW and the tabulated data would be applicable to that output.

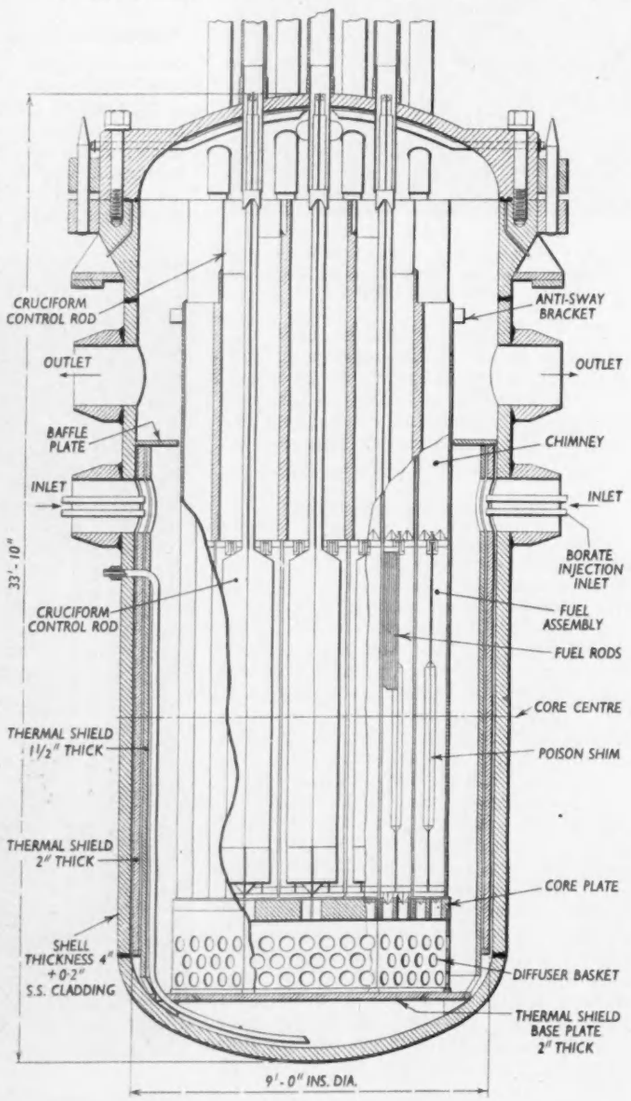
The $14{\cdot}0 \times 10^6$ lb of primary coolant enters the reactor vessel at 520·4 deg. Fah. and travels upwards through the core absorbing 90·9MW of sensible heat in the lower part of the core and 65·1MW of latent heat in the upper part of the core.

If the ratio of steam velocity to liquid velocity is 1·2 to 1·0, this results in an average of 7·3 per cent steam voids in the core. The steam and water mixture produced thereby leaves the superstructure above the reactor core and passes through the four outlet pipes to the primary separators, from which steam passes to the condenser heat exchangers and water to the sub-coolers. The primary condensate from the condenser heat exchangers mixes with the primary water at the sub-cooler outlet and is returned to the reactor vessel, by means of the primary circulating pumps, traversing the annular space between the reactor vessel shell and the core shrouding and passing through the diffuser basket into the base of the core. The secondary flow of 534,000 lb per hour is fed to the sub-coolers at 240 deg. Fah. and partly

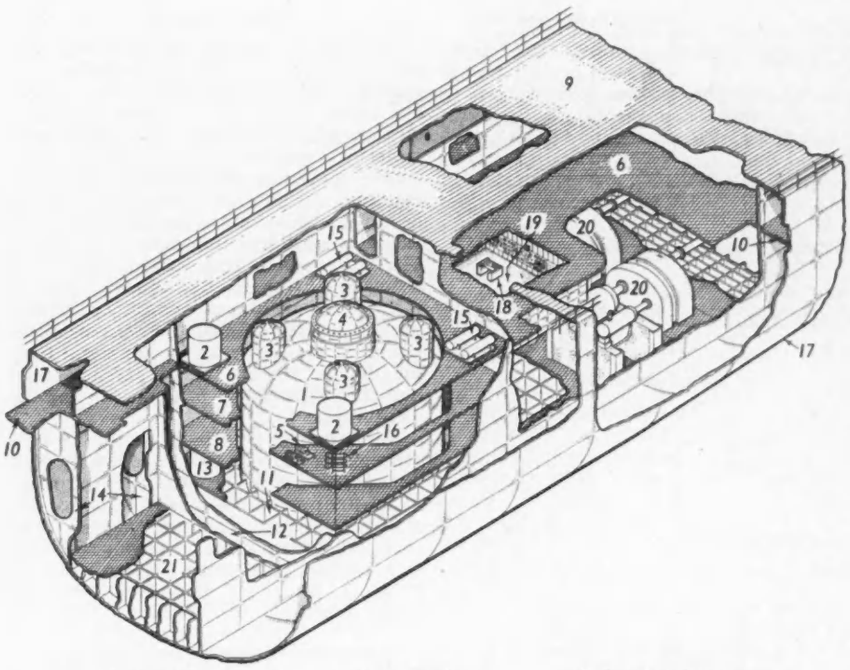
Main Particulars of Mitchell-Fairfield-Combustion Engineering Closed-Cycle Boiling-Water Reactor

Reactor thermal output	156MW
Operating pressure	950 lb per square inch absolute
Active core volume, total	287 cubic feet
Fuel rating	8·75kW per kilogramme of uranium
Power density, average core	19kW per litre
Weight of UO_2 fuel	43,618 lb
Initial enrichment	2·55 per cent U-235
Effective length of core	94in
Effective radius of core	41in
Burn-up	11,023kWD per kilogramme
Turbine steam rate	7·972 lb per hour per shaft horsepower
Reheater steam rate	0·87 lb per hour per shaft horsepower
Heat consumption rate	9650 B.Th.U. per hour per shaft horsepower
Vacuum	28in Hg.
Sea temperature	75 deg. Fah.
Primary coolant pressure	950 lb per square inch absolute
Primary coolant saturated temperature	538·4 deg. Fah.
Primary coolant flow rate (total)	14,000,000 lb per hour
Primary steam production	337,000 lb per hour
Secondary fluid pressure	650 lb per square inch absolute
Secondary saturated temperature	496 deg. Fah.
Secondary fluid flow rate	534,000 lb per hour
Secondary feed water temperature	24 deg. Fah.





Figs. 15 and 16—(Left) Model of the Mitchell-Fairfield-Combustion Engineering boiling-water-reactor propulsion system for ships. (Right) General arrangement of reactor vessel



1—Lead clad containment vessel.
2—5000-gallon resin storage.
3—Personnel hatch.
4—Refuelling vessel closure head.
5—Purification loop pumps.
6—Top deck.
7—Second deck.
8—Lower deck.
9—Bridge deck.
10—Walkway.
11—Programming tanks.
12—Cofferdam.
13—Resin disposal tank.
14—Collision plates.
15—Secondary separator.
16—Regenerative feed heater.
17—Hull shell.
18—Controller's station.
19—Control room.
20—Turbine.
21—Cargo tanks.

Fig. 17—Cut-away view of reactor containment and propulsion area

boiled therein at 496 deg. Fah., 650 lb per square inch absolute before passing to the condenser heat exchangers where boiling is completed. The secondary steam is then dried in moisture separators in the reactor room before passing into the engine-room.

Reactor Details

Reactor Core.—The reactor core comprises 216 fuel assemblies (Fig. 19) each of which contains fifty-six fuel rod elements. A fuel element consists of a 0·366in inner diameter stainless steel tube, of wall thickness 0·015in and approximately 8ft long, filled with cylindrical uranium dioxide pellets, bonded with helium gas and sealed at both ends by a welded cap. Two kinds of elements are used within each assembly. One contains 2·55 per cent enriched UO_2 pellets. The second contains half enriched UO_2 pellets and half natural UO_2 pellets. Elements of the second kind would be placed at each corner of fuel assemblies to control hot spots caused by the high flux in the water channels outside the fuel boxes and to reduce axial neutron flux variation.

The fuel elements are guaranteed for a burn-up of 11,023kWD per kilogramme.

Control Rods.—To obtain adequate control of the reactor, twenty-one control rods fabricated from three different combinations of neutron absorbing materials would be used as follows :

(i) The centre rod. The poison section of this control rod is liable to be in the core rather more than any other control rod and is therefore made entirely of hafnium.

(ii) The four control rods surrounding the centre. For these rods pure hafnium would be used for approximately 60 per cent of the poison section and the remainder would be made of boron stainless steel ; i.e. stainless steel containing 2 per cent by weight of natural boron.

(iii) The scram rods. These rods are the remaining sixteen outer rods, and as they are normally held full out of the core and only used for reactor scrams, the poison sections would be entirely made of boron stainless steel.

The poison length of each rod takes the form of a 15in span cruciform cross-section which moves up or down in the centre of a group of sixteen fuel assemblies. An extension rod is riveted to the top of each control blade with a stainless steel coupling at the upper end for connecting the control rod to the drive rod of the actuating mechanism.

Reactor Pressure Vessel.—Fig. 16 shows a longitudinal cross section of the reactor vessel with the core and other internal fittings in position.

The reactor vessel is vertical, cylindrical, and has an inside diameter of 9ft and a length over the heads of approximately 23ft 10in. The vessel weighs about 90 tons, including the internals but excluding the core and control rods. It is built of carbon steel 4in thick and clad with stainless steel 0·2in thick. The parallel length of the reactor vessel is approximately 19ft 4in and the shell is closed at the lower end with a normal head.

The upper end of the shell, through which pass the control rod drive mechanisms, is welded to a bolting ring forging holding the hold-down studs for the removable closure. The parallel portion of the shell is of welded plate construction, fabricated from clad plate. Nozzles are built into the pressure vessel for forced circulation of water to cool the core. Four large moisture outlets and four inlet nozzles, 20in and 18in nominal bore respectively, penetrate the reactor vessel. All the control rods will be actuated from the top of the vessel through twenty-one 6in pipe thimbles approximately 9ft in length.

Internal thermal shields consisting of two concentric cylinders of stainless steel, line the pressure vessel over a height of 13ft 6in. The outer shield is 2in thick, 103in inside diameter, and the inner one 1½in thick, 99in inside diameter, with a ½in water gap between them.

Core Diffuser Basket.—A core diffuser basket supports the core and serves as both a spacer between the thermal shield and the bottom of the core, and as the diffuser deflector basket. It consists of a 1½in thick stainless steel octagon 20in tall, perforated with 128 holes 4½in diameter, spaced on a 6in triangular pitch. This basket is supported by a 6in by 4in triangular-sectioned annular flange of 7ft 9in outer diameter, welded to the reactor vessel wall. This flange, which is made of stainless steel, also supports the internal thermal shields.

Core Plate.—The core plate is a cast stainless steel plate, 6in thick, made to follow the shape of the diffuser basket. It has orifices to control the distribution of water to the fuel assemblies. The fuel element seating fixtures are mounted on top of the flow orifices.

Core Shroud and Superstructure.—The core shroud and superstructure (Fig. 18) is made in stainless steel plate and acts as a support for the fuel assemblies and as a guide for the coolant flow and control rods. It is supported on the core plate.

Primary Separator Drum.—Each of the four primary coolant loops includes a separator in the form of a 4ft 6in inner diameter mild steel drum 6ft 6in long parallel length and lined with stainless steel. The stainless steel internals include a large quadrant vane extending through the operating length to prevent surges, and " egg box " baffles at the lowest point to prevent vortex formation.

Condenser Heat Exchangers.—The condenser heat exchangers are built up of concentric tubes, designed to condense 90,000 lb per hour of primary steam on the shell side. The secondary water passes down the central ½in-outer-diameter tubing and feeds the annulus between the tubing, and in rising up this annulus it receives heat from the condensing primary steam and is thereby evaporated. Each condenser heat exchanger is about 21ft 6in long and 4ft 6in inside diameter.

Sub-Coolers.—The sub-coolers are 2/2-flow hairpin tubes, with the primary fluid flowing through the tube side and being sub-cooled therein. On the shell side, the sub-coolers receive the main feed water at 240 deg. Fah. and this is heated to saturation temperature before passing into the condenser heat exchangers. Each sub-cooler is approximately 17ft 6in long and 4ft 6in i.d., and is designed to cool 3,500,000 lb per hour of primary water from 538·4 deg. Fah. while heating 149,000 lb per hour of secondary water fed at 240 deg. Fah.

Forced Circulation Pumps.—Each of the four circulating loops for the nuclear reactor is fitted with a forced circulation pump of the canned motor type. Each pump unit consists of a single stage centrifugal pump driven by a squirrel-cage induction motor. The motor is an integral part of the pump and is filled with the water being pumped through the main circulating loop. No stuffing-box or seal is provided on the rotating pump shaft.

Shielding Design

The two main radioactive sources of the system are, first, the reactor core, and, second, the primary circuit equipment. Essentially, the primary biological shield comprises a 3ft 6in wide, annular borated water tank extending throughout the height of the reactor vessel. In addition to this, the shielding in a radial direction from the core throughout a distance several feet greater than its height consists of approximately 4½in stainless steel, 7in light water, 15in mild steel, 4in stainless steel thermal

insulation, 19in air gap and 1in lead. This material is not arranged in the sequence quoted above, but the figures are listed to give an appreciation of the material required without causing confusion by detailing individual thicknesses.

Shielding in the radial athwartships direction is supplemented by a 2ft 6in thickness of light water formed by the quench tanks. The objectives of this shield are fourfold.

1. To ensure that the core neutron flux is attenuated to such a level that the dose outside the containment compartment is a small fraction of the tolerance level.

2. To bring the core gamma radiation down to such a level that, after being attenuated in the secondary shield, the final activity will be below the required tolerance level.

3. To provide a safe tolerance level (in the containment compartment) from fission product gammas after shut-down.

4. To reduce the dose due to residual gamma activity in the stainless steel components to safe level after reactor shut-down.

The main secondary shield structure is the containment vessel on to which is applied lead of varying thickness from 3in to 6½in, depending on the radiation levels within and permissible levels without. Local shielding round particularly active equipment supplements the main shield and the whole arrangement is designed to ensure safe tolerance levels for particular compartments outside its surface by attenuating activity arising from the following sources :—

1. Gamma radiation in the primary circuit, due to N 16 decay activity.

2. The core gamma radiation after attenuation through the primary shield.

3. Neutrons in the primary circuit due to N 17 decay activity.

In addition to these two main shields, further local shields are necessary to this design ; the most important are the ion exchange column shields and the shielding of the control room.

Containment Compartment

The containment compartment is designed to house the reactor proper together with the four primary circulating loops and associated equipment. In shape it approximates to an ellipsoidally headed, flat-bottomed cylinder.

It performs four main functions : first, containment of radioactive fluids in the event of a maximum credible accident ; secondly, containment of radioactive fluids in the course of normal operation ; thirdly, support for secondary shielding ; and, fourthly, additional protection for core in case of hull damage.

For the maximum credible accident the expected maximum containment internal pressure is about 104 lb per square inch gauge, and allowing a 25 per cent design margin the design pressure is 130·1 lb per square inch gauge. SA 212B mild steel is specified as the material for the shell and this material has a yield point of 38,000 lb per square inch. As the use of the containment compartment at its design pressure is considered to be a very unlikely event, and without doubt very rare in the lifetime of the shell, and even then for a limited period only, the allowable design stress is taken to be two-thirds of the yield stress, i.e. 25,300 lb per square inch. The compartment shell has an inside diameter of 46ft and an overall height of 50ft 2in, and inner and outer cylindrical ring bulkhead, well tied to the containment shell, is incorporated forming the biological shield. The compartment head is 2 : 1 semi-ellipsoidal, connected to the inner cylindrical bulkhead and locally

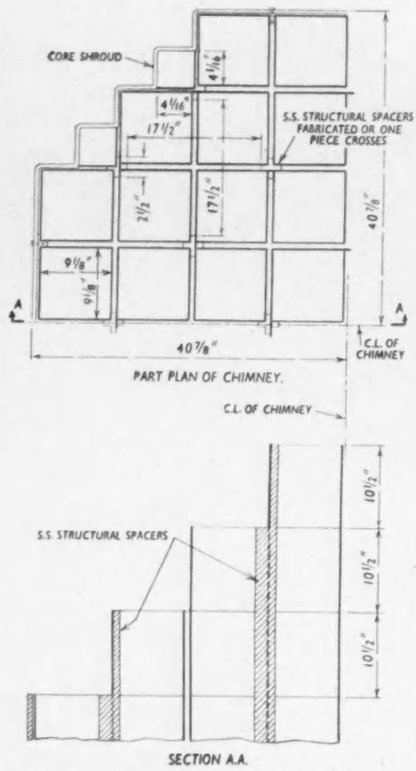


Fig. 18—General arrangement of core shroud

increased in thickness (as compensation) where openings occur, i.e. round the machinery shipping trunks and all smaller penetrations. It is anticipated that there will be twenty-eight pipes and one cable trunk penetrating the containment.

When the reactor is in operation, there will be no necessity for access to the containment compartment ; therefore, admission will be prohibited under all reactor operating conditions. After shut-down, a period of thermal cooling and radioactive decay will be allowed, and then the air within the containment compartment will be flushed out before opening the access hatches. Thereafter, accessibility will be allowed in accordance with health physics regulations.

Two access hatches are provided, large enough for the passage of personnel and replacement parts should any be required ; they are situated to allow a straightforward route to all components and to give an effective airflow during flushing.

Main Engines

The main propulsion unit proposed consists of two sets of turbines, condensers and gearing. Each set includes an h.p. ahead and astern turbine, an l.p. ahead and astern turbine, placed outboard and inboard respectively, together with a two-flow regenerative condenser athwartships and allowing tube withdrawal outboard. Double helical, double reduction gearing is proposed. An articulated gear train will be driven by the h.p. turbine and locked train gear arrangement from the l.p. turbine. Between the h.p. turbine exhaust and the l.p. turbine inlet, a separator followed by a reheater is placed in the line, enabling the steam leaving the h.p. turbine to be partially dried and then superheated prior to entering the l.p. turbine.

The h.p. turbine will be controlled by a sequential nozzle control valve arrangement incorporating a by-pass to cover the range of 80–100 per cent full power. Control and instrumentation of the main engines, however, will be brought to a standby condition from within the machinery spaces and then remotely controlled throughout the full range of power.

Waste Disposal and Fuel Handling

Equipment is provided to dispose of liquid, solid and gaseous wastes which arise in the operation of the primary system, and is designed to consume internally as much waste as possible, so that the only stored waste is spent ion exchange resin and a small amount of contaminated water. It would not be necessary at any time to discharge radioactive waste at sea, and such waste may easily be stored for discharge at a convenient time, such as at time of " annual " refit when disposal could be in the manner of land-based practice.

The design of the reactor would permit operation at 80 per cent full power for a period of about three and a half years. However, to obtain a uniform burn-up of the fuel in the core, it is proposed that " shuffling " of the fuel elements should take place at twelve or fifteen months' intervals, during " annual " refit. No attempt could be made, nor would be necessary, to handle fuel elements at sea.

Safety

The safety provisions can be summarised in twelve points.

1. Negative void coefficient of reactivity and negative temperature coefficient of

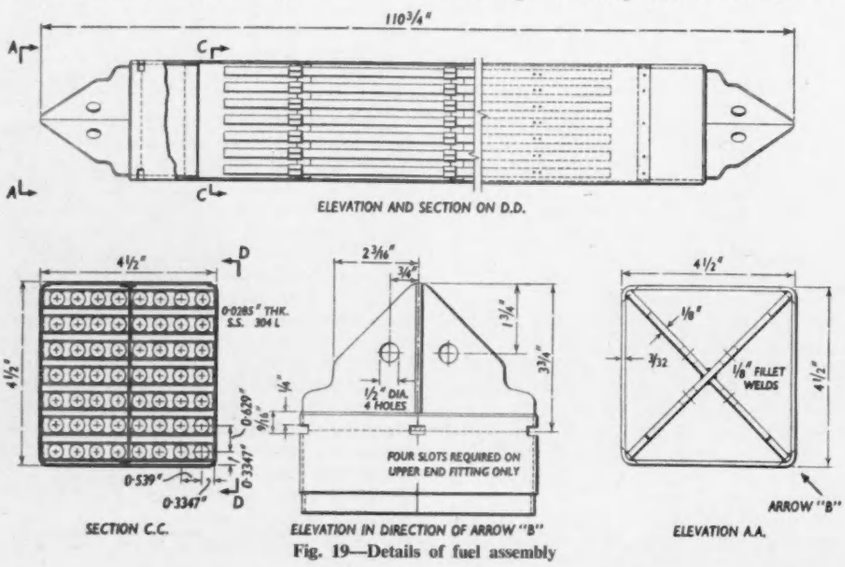


Fig. 19—Details of fuel assembly

reactivity give the reactor self-limiting power characteristics.

2. Control rods at all times maintain the reactor under proper control at constant pressure.

3. Scram rods shut down the reactor rapidly in hazardous conditions.

4. Pressure relief system, safety valves ensure that dangerous pressures are not developed anywhere in the system.

5. A liquid borate injection system ("poisons") shuts down reactor in emergency if control rods and scram rods fail to do so.

6. Isolating valves localise spread of radioactivity in accident conditions.

7. Emergency decay heat system provides decay heat removal cooling, even if all power sources fail.

8. Emergency reactor spray prevents core meltdown if primary coolant lost.

9. Closed cycle system confines all radioactive fluid to the reactor room.

10. Containment compartment contains all radioactive fluid in event of maximum credible accident.

11. Start up interlocks prevent cold start-up accident.

12. Containment compartment spray provides emergency cooling and protection against fire risk.

(*To be continued*)

Measuring the Diameter of Very Small Bores*

By P. W. HARRISON, B.Sc. (Eng.), A.M.I.Mech.E., A.C.G.I., and G. M. SEVERN

A prototype instrument has been developed at the National Physical Laboratory for measuring very small bores. Although simple in conception, it is nevertheless capable of measuring bores down to 0·03in (¾mm) in diameter and 1½in (40mm) in length to an accuracy of about ±0·000 02in (±½μm), provided that the surface finish of the wall of the bore is good. The use of very slender styli for precise measurement is usually accompanied by difficulties which arise due to bending of the stylus stem when the measuring load is applied. In this apparatus these have been overcome by the use of a sensitive electronic device which reduces the measuring force at the stylus tip to such a value that the resulting deflection of the stem is negligible. A further difficulty due to slight magnetisation of the workpiece causing the stylus to cling to the wall of the bore has been met by coating the tip of the stylus with a thin non-magnetic layer which adequately reduces the attractive force on the stylus.

Principle of Operation

IN principle, a spherically ended stylus of known size is moved from one end of the diameter to be measured to the other, this movement being determined in some suitable manner. The bore diameter is then given by the sum of the stylus diameter and the stylus displacement. It is at once apparent that the introduction of a measuring stylus into a long fine bore necessitates the use of a very slender stem. Under the influence of a measuring force of the order of magnitude commonly employed in precision apparatus, the stylus would bend very considerably, and to obtain an accurate determination of bore diameter it would be necessary to make a precise determination of the degree of bending or, in some manner, compensate for it. Both procedures are somewhat unsatisfactory due, principally, to the difficulty of applying a measuring force at the point of contact between stylus and bore which is known with sufficient accuracy. In addition, if the stem deflection were determined theoretically, any lack of homogeneity in the material or dimensions of the stem could cause the true deflection to depart from the calculated value. In this apparatus, the problem has been solved by reducing the measuring force to a value which produces negligible bending by using a sensitive electronic device to sense the contact of the stylus with the bore wall.

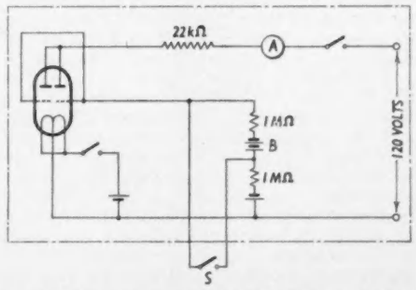


Fig. 1—The contact sensing circuit. The contact of a spherically ended stylus with the bore is simulated in the diagram by the switch *S*

Contact Sensing Device

The circuit adopted for this device, which is similar to one described in 1922 by Dr. G. A. Tomlinson,[1] is based on a double-triode valve with corresponding electrodes strapped together (see Fig. 1). The anode current is supplied from a dry h.t. battery through a 22kΩ resistor, and the filament current from a 1½V dry cell. With no contact between the stylus and the wall of the bore, the grids are negatively biased to give a standing anode current of ¼mA. When contact is made the bias is reduced by 3V so as to increase the anode current to 1¼mA. This reduction of voltage is achieved by arranging that the contact (represented by *S* in Fig. 1) short circuits the dry battery *B* and the 1*M*Ω resistor in series with it. The current through the contact is therefore limited to a few microamperes so that welding or pitting of the contact is virtually eliminated. The change of anode current is shown on the milliammeter *A* (Fig. 1). This milliammeter can be seen at the centre of Fig. 2, which is a general view of the apparatus.

Experience showed that to obtain reliable, positive signals from the contact sensing device very careful cleaning of the contacting surfaces was essential ; the best results have been obtained by applying benzene followed by chloroform, although carbon tetrachloride has been found to be quite satisfactory. Long bores, inaccessible to a brush, have been cleaned by using a string "pull-through," soaked in the solvent. Even so, it was apparent occasionally that the surface remained contaminated with a thin residual film which prevented good electrical contact unless the force on the stylus was increased to a value sufficient to deflect its stem to an unallowable extent. The preferred procedure is, therefore, to make contact and then withdraw the workpiece from the stylus until the milliammeter indicates that the circuit is just broken. However, further experience with the prototype instrument revealed that, whilst this procedure was perfectly satisfactory for workpieces made of non-magnetic materials, when measuring workpieces which had even a slight degree of magnetisation, the stylus clung to the bore wall and deflection of the stylus stem was required to make it break away. This deflection often did not amount to more than a few hundred-thousandths of an inch, but was nevertheless unacceptable having regard to the accuracy of performance sought. Since the normal procedure of passing the workpiece through a demagnetising coil was not found to be wholly effective, this difficulty was solved for the common ferrous materials by plating the spherical

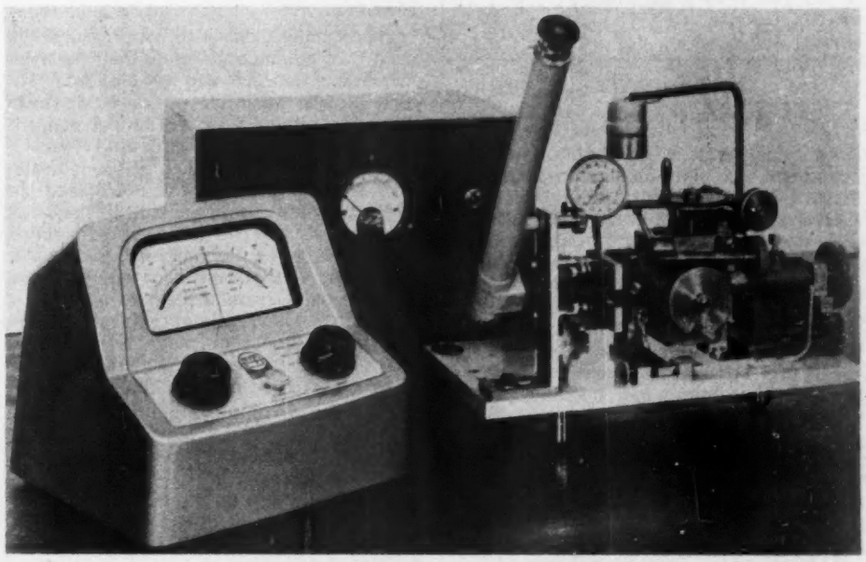


Fig. 2—The complete equipment consists of three units : a Magna-Gage comparator, a contact sensing device, and a slide and stylus assembly respectively

* Communication from the National Physical Laboratory, Teddington.

stylus tip with a non-magnetic coating, approximately 0·000 15in (4μm) thick, consisting of rhodium deposited on interlayers of nickel and copper.

Measuring Stylus

The stem of the stylus is made, for strength, of tungsten wire, the end of the wire being reduced and slightly tapered to enter a hole of about 0·006in (150μm) diameter in a spherical steel ball. The hole is produced by the spark-erosion process. The most slender stylus so far made has a ball of 0·02in (½mm) diameter mounted upon a stem ¾in (20mm) long and 0·010in (¼mm) diameter. Measurement of the ball diameter is made on an interferometer particularly developed at this laboratory for such purposes. It is hoped to make styli both smaller in diameter and longer in the stem.

General Description of the Apparatus

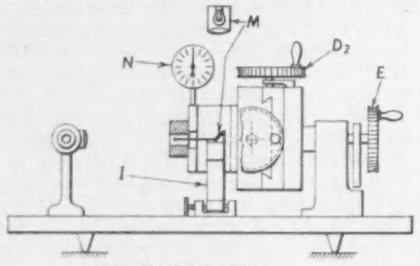
The essential features of the prototype apparatus into which the stylus has been built are :

(1) Suitable means for bringing the workpiece and stylus into correct relationship.

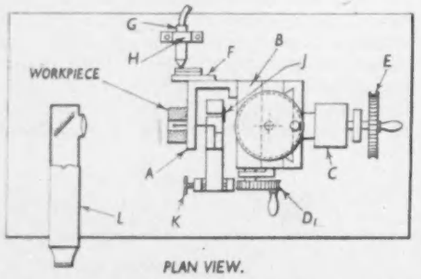
(2) Means to measure the relative diametral movement of stylus and workpiece.

(3) An optical system to enable the observer to view the stylus in the bore.

These features may be identified by referring to Fig. 2 and Fig. 3. In practice, it has



FRONT ELEVATION.



PLAN VIEW.

Fig. 3—Arrangement of the slide and stylus assembly

been found more convenient to move the workpiece, the stylus remaining stationary. Accordingly, the face plate *A* has been rigidly attached to the double cross slide *B*, which is supported in the bearing *C*. Workpieces of differing size and shape can be accommodated, and in the illustrations a ring gauge is shown mounted on the face plate and held to it by spring clips. A particular feature of the double cross slide is that very fine movements may be imparted to each of the slides by the use of worms and worm wheels (D_1 (and D_2) to rotate the traversing screws which have forty threads per inch. When making coarse adjustments the worm wheel and worm can be disengaged. Movement of the workpiece parallel to the bore axis is provided by the screw *E*.

The face plate is formed at one end with a lapped face *F* to which slip gauges may be wrung. The anvils of a Magna-Gage electronic gauging head *G* may be brought into contact with the slip gauges by sliding the head through the supporting bracket *H*. In order to minimise the effect of any errors in the slide motions, the axis of the head is arranged to lie horizontally in a plane square to the workpiece axis and, if extended, would pass through the centre of the spherical end of the stylus. The amplifier unit associated with this measuring head has a zero-setting control which provides a range of adjustment equivalent to about seven times the full-scale reading on the meter. The usefulness of this feature will be apparent later. The stylus is rigidly attached to, but insulated from, the column *I*. In order to bring the stylus stem accurately parallel, in the horizontal plane, to the axis of the workpiece, the column *I* may be swung about the hinge *J* by the adjusting screw *K*. The insulating block carrying the stylus is so fixed to the column *I* that coarse adjustment of the stylus stem in the vertical plane is also possible. To provide the observer with a view of the stylus in the bore, a simple optical system is fitted to the apparatus comprising a telescope, mirror and weak field lens constructed as a unit *L*, illumination being provided by a small torch bulb, lens and 45 deg. mirror *M*. When viewed through the telescope, the stylus appears as a dark disc on a light background. The dial indicator *N*, which may be swung out of position when not required, is so mounted that it registers the motion imparted to the face plate by the vertical slide.

Observational Procedure

The risk of damage to the stylus when mounting the workpiece is minimised by displacing the face plate towards the telescope until the stylus no longer protrudes beyond it. The bore to be measured is then mounted on the face plate with its axis reasonably square to the face plate and at about the height of the stylus. Whilst observing the stylus and bore through the telescope, the stylus is brought approximately on to the bore axis by appropriate movement of the double cross slide and is then introduced into the bore by moving the face plate away from the telescope until the stylus point lies in the desired plane of measurement. A scale is fitted to assist in making this setting. A check is then made by direct observation that the stylus stem does not touch the wall of the bore when the stylus tip is brought into contact with it. If necessary, the stem is aligned to attain this condition.

Precise adjustment of the workpiece height must then be made to ensure that the stylus measures a diameter and not a chord. The method is to move the workpiece upwards, using the vertical traverse, until it contacts the stylus and then downwards until contact is again made. The readings of the indicator *N* in the two positions are noted, and the workpiece moved until the indicator registers the mean of these two readings. In practice, because of the limited range of the indicator used, these settings were made with the stylus offset in the horizontal plane to one side of the bore. The precision with which this adjustment should be made is related, of course, to the accuracy of diametral measurement required and the bore diameter.

Two slip gauge piles are next prepared differing in size by an amount equal to the difference between the nominal bore diameter and the diameter of the stylus tip. With the smaller pile wrung to the face *F*, the workpiece is moved towards the gauging head *G* until, to the observer, the stylus appears to be just in contact with the bore. The head is then brought into contact with the pile until the pointer on the meter associated with it registers somewhere near the centre of the scale.

The electronic sensing device is then used in setting the bore in precise relation to the stylus, the procedure, as mentioned earlier, being first to obtain a positive electrical contact and then just breaking the contact by slow retraction of the workpiece. By means of the zero-setting control the reading of the meter of the Magna-Gage can be restored, if necessary, to an approximate mid-scale value and this value then noted. The workpiece is then displaced in the opposite direction and the larger slip gauge pile substituted, leaving the measuring head undisturbed. After following a similar procedure for setting the opposite wall of the bore and the stylus in correct relationship, the meter reading is again noted. The earlier setting with the smaller slip gauge pile is then repeated to verify that this setting has not changed. The bore diameter is derived by associating the differences between the two meter readings with the difference between the two piles of slip gauges and the diameter of the stylus tip.

Acknowledgments

The authors are indebted to the Armament Research and Development Establishment, Fort Halstead, and the Central Workshop, N.P.L., who jointly developed the technique for accurately boring the very small holes in the ball tips for the many experimental styli.

The work described above has been carried out as part of the research programme of the National Physical Laboratory, and this description is published by permission of the Director of the Laboratory.

Reference

[1] Tomlinson, G. A., 1922, "The Use of a Triode Valve in Registering Electrical Contacts," *Phil. Mag.*, XLIV, 870.

Appointments Service for Professional Engineers

Following discussions between the Council of the Engineers' Guild and the Board of the Professional Engineers Appointments Bureau, it has been agreed between the two bodies that the functions of the Bureau shall be transferred to the Guild, which will carry them on in future. An appointments division will be created in the Guild Office to carry out these functions for corporate members, graduates and students of the Institutions of Civil, of Mechanical, of Electrical and of Chemical Engineers, and the present Registrar and Secretary of the Bureau, Mr. J. Muil, M.I.E.E., and assistant secretary, Mr. H. Bailey, are being invited to join the Guild secretariat as Registrar and Assistant Registrar respectively of the new division. The work of the division will be controlled by a Professional Engineers Appointments Board, appointed by and responsible to the Council of the Guild. The Professional Engineers Appointments Bureau was formed in 1945 with the support of industry and the engineering Institutions, and it has established itself as one of the channels through which professional engineering appointments are now filled. In undertaking this additional responsibility, the Council believes that it will be advancing its objects to promote the unity, public usefulness, honour and interests of the engineering profession, and confirms that the services of the appointments division will be available to members of the profession whether or not they are members of the Guild. There is no intention of increasing the current scales of fee. Final details of the transfer are still being discussed and a further statement will be made in due course, including the names of the members of the profession who have been appointed to form the new Board. It is hoped that the arrangements described will take effect on June 1, but the appointments division will continue to operate from the present address of the Bureau, 39, Victoria Street, London, S.W.1 Abbey 1737), until further notice.

International Transistor Exhibition

No. II—(*Concluded from page 803, May 22*)

The International Transistor Exhibition, held at Earls Court, London, in connection with the International Convention on Transistors and Associated Semiconductor Devices promoted by the Institution of Electrical Engineers, terminated on Wednesday, May 27. There were eighty-three stands, among which were displays representing transistor development in eight overseas countries. Referring to the exhibition in his speech when opening the convention, Lord Hailsham, Lord President of the Council, expressed the hope of the organisers that it might attract students to electronics as a career, and recalled the invitations which had been sent to schools and colleges to bring parties of their senior scholars and students. A final selection of exhibits is reviewed below.

STANDARD TELEPHONES AND CABLES, LTD.

TWO special exhibits on the stand of Standard Telephones and Cables, Ltd., Connaught House, Aldwych, London, W.C.2, showed the use of transistors in electronic circuitry. The first of these, a slow speed ferrite store, uses 180 transistors and 320 diodes in its control circuits. The circuits operate in conjunction with a ferrite matrix plane. Telegraph characters (up to thirty-two in number) are transmitted from the associated teleprinter into the store. The characters are held until retransmission to the teleprinter is released by a manually-operated switch. The second of these exhibits, a micro model, uses about 350 transistors and 1500 diodes in its circuitry. It has been produced to demonstrate the method of assembly of STRAD (Signal Transmission Reception and Distribution system) electronic circuitry and the reliability of transistorised circuits. Basically the model is made up of two binary counters, which are operated simultaneously under normal conditions ; they are started together and should always remain in step. Manual controls are provided for starting and stopping the counters, and either or both counters can be reset if required. Should the counters become out of step, a comparison circuit operates an alarm system.

In addition to the special exhibits, a number of transistorised, or part-transistorised, equipments by the company were shown. From the Transmission Division, these included the 300-circuit small-diameter coaxial cable telephone system, and a transistorised carrier telephone system for rural service. In the former equipment (Fig. 5) a fully transistorised dependent repeater forms one stage of a 300-channel small-diameter cable system ; its operation is dependent upon power fed over the cable itself. To ensure good temperature stability, the repeater is buried below ground, and provision is made for withdrawing the internal unit to the surface for servicing. The system meets C.C.I.T.T. recommendations for international circuits.

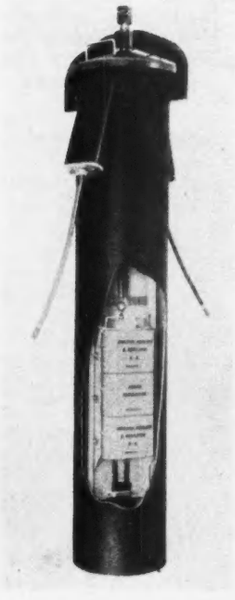


Fig. 5—" Cut-away " view of transistorised underground repeater equipment—Standard Telephones and Cables

The rural telephone transmission system is designed to meet the needs of scattered locations in sparsely-populated areas. The design enables any number up to ten two-way speech circuits to be provided over a single open-wire pair. The use of junction transistors, combined with modern components and assembly techniques, provides equipment requiring greatly reduced space, and permits operation on a nominal 24V d.c. supply. Also shown was an exhibit from an associated company, Fabbrica Apparecchiature per Comunicazioni Elettriche-Standard (FACE) of Milan. This consisted of a hand-free telephone set, being a normal-size telephone set incorporating a microphone and a fully-transistorised amplifier. This, combined with a small external loudspeaker, allows the telephone user to speak and to listen without removing the handset from its place, thus leaving the hands completely free.

Exhibits on the stand from Standard Telecommunication Laboratories included a demonstration of a transistorised theodolite, comprising transmitter, intermediate position, and receiver. The transmitter and receiver are placed at opposite ends of a visual path, for which the minimum length could be as little as 6ft and maximum operating length as much as half a mile. With this equipment it is possible for one man, without assistance from the end of the line, to establish the exact position at which the line of sight passes over his location.

Among the Rectifier Division exhibits were a display of silicon devices and germanium photocells, a zener diode semi-automatic test set, power supply units for carrier equipment, and a working demonstration of zener diodes. The Capacitor, Information Processing, and Radio Divisions of the company all contributed examples of apparatus using transistors or particularly applicable to transistor circuits.

DAWE INSTRUMENTS, LTD.

A transistorised device of wide engineering application on the stand of Dawe Instruments, Ltd., Uxbridge Road, Ealing, London, W.5, was a portable battery-operated stroboscope (Fig. 6). This unit, known as the Type 1211 " Stroboscope," has been designed specifically for use in locations where a mains supply is not available. It is expected to prove of particular value in the automobile, aircraft, and textile industries, as the power requirements can be drawn not only from the mains supply or the recommended battery pack, but from any 12V d.c. source capable of supplying 1A (for example, the battery of any vehicle with a 12V electrical system). The design incorporates a transistor multivibrator circuit used to provide a pulse output, the repetition rate of which is controlled by a potentiometer through a slow-motion drive from the front panel. This output, after differentiation and amplification, is applied to a step-up transformer to provide the necessary high voltage pulse to trigger the flash tube.

The pulses are also used to operate a frequency meter circuit, to give a direct indication of the flashing rate on a meter scale calibrated in revolutions per minute. Flashing rates between 600 and 15,000 per minute are covered in two ranges, 600 to 3000 and 3000 to 15,000.

A 12V accumulator in a leather carrying case, as shown in the illustration, can be supplied as the power source. On battery operation the h.t. supply for the flash tube is provided by a transistor d.c. converter operating on the push-pull saturating core principle. The " Stroboscope " can also be operated from normal 200V–250V, 50 to 60 c/s mains supplies. Measuring only 5¼in by 3½in by 7⅝in in its metal cabinet, and weighing 4 lb, the instrument can conveniently be held in the hand.

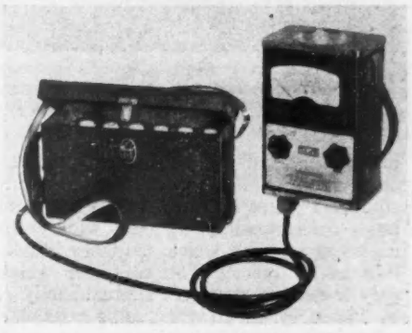


Fig. 6—Portable stroboscope equipment, incorporating transistor multivibrator—Dawe Instruments

An all-transistor oscilloscope, Type 720, was also shown. It is completely portable, the power supply being a small 6V accumulator contained in the cabinet. For bench use the mains supply may be used to float charge the accumulator. In its present form the oscilloscope is intended primarily for the measurement and study of waveforms encountered in the vibration and acoustic fields. It may also be used as a general purpose oscilloscope up to frequencies of about 50 kc/s. The 6V battery supplies the heater of the tube and also drives a d.c. converter giving outputs of 1300V and 30V d.c. for the tube e.h.t. and transistor circuit supplies respectively. The time base consists of a variable frequency multivibrator having a pulse which, after amplification, is used to charge a capacitor. This discharges through a constant current drain. The amplifier comprises three stages and provides the drive to the tube from a transistor in the grounded base configuration.

Other exhibits included oscillators and a transistor frequency meter which can be used in conjunction with a photo-transistor pick-up for the measurement of rotational shaft speeds up to 100,000 r.p.m.

Ferranti, Ltd.

A transistorised desk-size computer known as "Sirius" (Fig. 7) was shown by Ferranti, Ltd., Hollinwood, Lancs. The low power requirements of the transistors and the elimination of fans for cooling enable the equipment to be operated from a 5A power point, consumption being 3·8A, while ensuring silent working which simplifies installation in an office. The computer weighs only 5 cwt and measures approximately 7ft by 3ft 6in by 4ft high, including a standard office desk. Its chief application is expected to be to statistical analysis in industry, commerce, and in laboratories. Input is on paper tape, and a set of 100 buttons, similar to a desk calculator, is provided for use in programming or for modifying programmes already in use. Results are given in decimals. The "Sirius" computer exhibited was a prototype and, in addition to a punched tape output, gave an indicator-lamp display, mainly for monitoring purposes, in the form of binary digits, but the version to be marketed shortly will have a row of ten windows in which decimal numbers will be displayed. The present 1000-word capacity of the store will be increased later by the introduction of separate free-standing cabinets with plug-in connections to the main store. The built-in storage consists of twenty magneto-striction delay lines each with fifty words. Each word is ten decimal digits and each decimal digit is four binary digits.

Fig. 7—Transistorised desk-size digital computer, with associated printer, forming a complete computing equipment suitable for an ordinary office—Ferranti

The circuitry is built up with 600 logical elements known as "Neurons," each consisting of a printed circuit plate measuring approximately 5in by 6in (Fig. 8). These carry in all some 2000 transistors. The "Neurons" have been designed round the use of four-winding transformers in which the fourth winding provides an output dependent on the inputs to the other three. In this computer 85 per cent of the "Neuron" elements are of one basic type. They plug in at right angles to the logical network, the ends of the printed circuit wiring being terminated in flat contacts through which the connections are made. Testing is facilitated by the arrangement of loops in the wiring at certain parts of the circuit with provision for the attachment of a clip-on ammeter.

The "Sirius" computer is still the subject of development, one of the possibilities under consideration being its adaptation to accept instructions in the simplified "Autocode" developed for users of the company's "Pegasus" computer (see our February 13 issue, page 272).

Other features of the Ferranti stand included demonstrations of solar cells, one of which showed their response to very short-duration light pulses such as those derived from a high-speed stroboscopic light source.

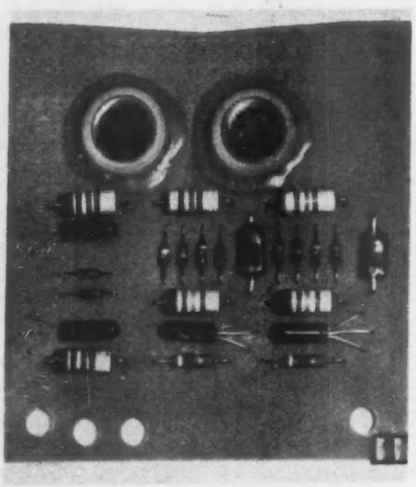


Fig. 8—Logic element of computer shown in Fig. 7. Two of the four-winding transformers on which the system is based are seen at the top—Ferranti

Westinghouse Brake and Signal Company, Ltd.

Three new semiconductor devices (Fig. 9) for switching and power control purposes were shown by the Westinghouse Brake and Signal Company, Ltd., 82, York Way, King's Cross, London, N.1. One of these, the "Trinistor" switch, is a high-power, three-terminal controllable silicon rectifier. If the base is made positive with respect to the cathode, the breakover voltage is progressively reduced with increasing base drive and will fall to a few volts with a base drive of approximately 2V to 5V at 25mA to 150mA. Full forward current can then flow with a forward voltage drop similar to that of a normal silicon diode. However, once forward current has begun to flow, the base drive may be discontinued if desired, since (apart from certain special circumstances) the base no longer has any effect on the characteristics. To turn the "Trinistor" off it is in general necessary to reduce the current below a certain minimum value known as the sustaining current, although turn-off by a base control signal is possible at low currents.

A demonstration was given of a.c. power control by two "Trinistors" in opposed parallel connection, each switched on by control current from a transistor driver circuit at a variable point in the half-cycle, and returning to the blocking condition at the end of each half-cycle. The voltage supplied to the load was thus controlled according to the conduction angle. A further demonstration showed speed control of a d.c. motor by adjusting the conduction angle of two "Trinistors" in a 2kW controllable rectifier circuit. To illustrate the use of a "Trinistor" as the static equivalent of an a.c. contactor with a holding contact, a "start" button was arranged to feed control current to the "Trinistor" base and this current was maintained by feedback from the load. The "Trinistor" contactor was tripped by breaking the feedback path with a "stop" button. In this demonstration a single "Trinistor" switched an a.c. load of 1·6kW.

The "Dynistor" switch is a multi-layer p–n–p–m two-terminal germanium device having a breakover voltage characteristic which enables it to change from a high resistance (blocking) condition to a low

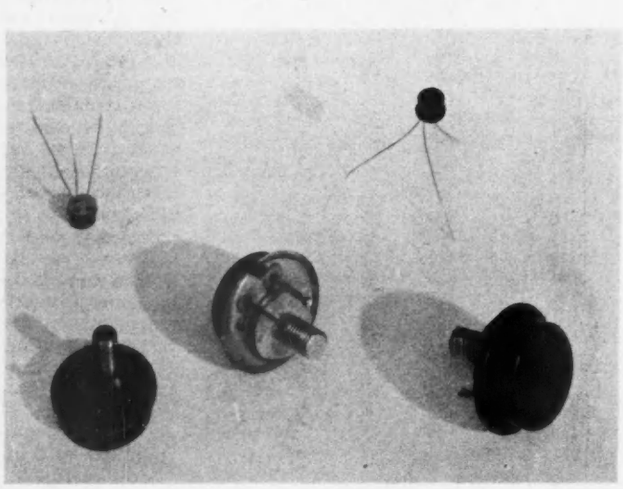


Fig. 9—New semiconductor switching devices showing germanium "Dynistors" (top), silicon power transistor (lower left) and silicon "Trinistors" (lower centre and right)—Westinghouse

resistance (conducting) condition in a fraction of a microsecond. The breakover may be initiated by a short-duration trigger pulse of less than 1 microsecond duration. To turn the "Dynistor" off it is necessary to reduce the current below a minimum value known as the sustaining current which is of the order of 20–50mA.

Also shown on the stand was a range of high power n–p–n fused silicon power transistors (Types TS10 to 26) with voltage ratings up to 300V and current ratings up to 5A.

Texas Instruments, Ltd.

A technique seen on the stand of Texas Instruments, Ltd., Dallas Road, Bedford, was an "ultramicroscopic" solid circuit in which diode and transistor elements, as well as passive elements of resistance and capacitance, are formed as integral parts of single pieces of semiconductor material, both silicon and germanium. The resultant solid circuits are each about the size of a match-head. One of the circuits shown was a multivibrator containing the equivalent of twelve electronic components—two diffused-base transistors, two capacitors and eight resistors—in a size less than $\frac{1}{4}$in by $\frac{1}{8}$in by $\frac{1}{32}$in. Such a size reduction gives an equivalent component density approaching 34,000,000 per cubic foot, comparing with an estimated 500,000 components per cubic foot for the so-called micro-modules, the highest announced hitherto. Resistors are formed by applying ohmic or non-rectifying contacts to a semiconductor wafer, and capacitors by using the capacitance of a relatively large area of a p–n junction. These two methods are combined for the formation of distributed capacitance. Diffused-base techniques are used for the portions of the solid circuit which function as transistors and diodes.

Ferguson Radio Corporation, Ltd.

A number of transistor-powered instruments was shown by the Ferguson Radio Corporation, Ltd., Great Cambridge Road, Enfield, Middlesex. An indicator developed to facilitate the adjustment of aero engines to an accurate predetermined speed illustrated the use of transistor digital techniques in instrumentation. The instrument determines the frequency of the signal from an engine-driven tachometer and compares it with the preset value, the difference being directly presented on the indicator. Frequency measurement is accomplished by counting pulses derived from the input for a fixed period, a crystal-controlled transistor oscillator providing the basis for timing. The reading is retained on the meter during counting, resulting in a continuous indication. A wide-band ferrite frequency multiplier is used in order to reduce the count time to only 1·2 seconds for an accuracy of 0·1 per cent at 70 c/s. The use of ferrite core/transistor circuitry results in a low power consumption of 2W from the internal mercury battery, giving an operating life of over 100 hours. A total of eighty transistors is used.

The development of a compact transistor amplifier with high gain, but low noise and drift, has enabled the company's Transistor Application Group to design a resistance-measuring bridge in which a mechanically robust and relatively insensitive moving coil instrument, with high overload capacity, is used without sacrifice of accuracy, and with great advantage in reducing the incidence of damage and replacements often experienced when semi-skilled operators are required to use sensitive galvanometers.

A transistorised waveform generator was shown (Fig. 10) which produces 405-line waveforms to B.B.C. Specification TV42. It provides trigger pulses for camera time bases and composite synchronising and blanking waveforms. Facilities are provided for crystal control or a wide-angle phase lock either to the internal mains or an external reference in the range 47 to 53 c/s.

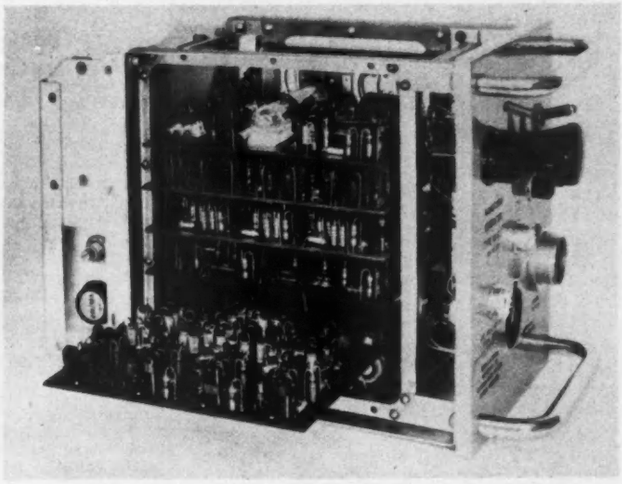


Fig. 10—Chassis arrangement of transistorised television waveform generator—Ferguson

Birlec, Ltd.

A new pilot dryer designed specifically to dry air and gases for transistor manufacture, atomic energy pilot plant, furnace atmosphere dewpoint control, stainless steel brazing and general process use, was exhibited by Birlec, Ltd., Erdington, Birmingham, 24. The dryer weighs 75 lb. It may be supplied with various desiccants, that for most common applications being activated alumina. In operation the unit is connected in circuit until the desiccant becomes saturated, whereupon it is removed from circuit and reactivated by a built-in heater system. The dryer takes the form of a round-ended cylinder of diameter 9in, and height 3ft 2in, with a desiccant capacity of 0·25 cubic foot. The reactivation temperature can be controlled at any desired level between 100 deg. and 300 deg. Cent. Reactivation heating takes some two and a half to five hours, and a cooling period of two to three hours is necessary.

English Electric Valve Company, Ltd.

A display of air-cooled, high-power germanium rectifiers on the stand of the English Electric Valve Company, Ltd., Chelmsford, Essex, was supported by examples of their application to providing filament supplies for large transmitting valves. In one of these exhibits six "VA710" diodes were shown forming a full-wave, bridge-connected rectifier giving an output of 480A at 9V for this purpose, or 160A per rectifier. The units were assembled in a framework with a fan attached for air cooling. Other applications showed germanium units arranged for supplying the solenoids of a 5MW magnetron and of a travelling wave tube. A water-cooled germanium rectifier with a current rating of 240A was also exhibited. An industrial application represented pictorially on the stand was the use of germanium cells for the drive of a rotary printing press.

United Kingdom Atomic Energy Authority

The central exhibit on the stand of the U.K.A.E.A. was a sensitive transistor oscilloscope with d.c. to 300 Mc/s response. The oscilloscope operates on the sampling principle, where the repetitive waveform to be observed is sampled for a very short interval of time once for each repetition. By slowly changing the instant of sampling in relation to the waveform itself, the whole of the waveform is examined progressively.

The time resolution of this system is determined solely by the duration of the gating pulse which controls the sampling action, and in the present case an avalanche transistor pulse generator is used to generate pulses of 1·5mμ second width, defining a bandwidth of 300 Mc/s and a rise time of 1·5 mμs for the oscilloscope. An advantage of the sampling technique is that after sampling the input waveform the information may be processed at a slow rate in low bandwidth circuits. The oscilloscope probe is arranged to contain all the high-speed circuits, namely, the gate pulse generator and the sampling circuit, and is connected to the main instrument containing the low frequency circuits by a length of multi-way cable.

The display oscillograph consists of a 21in television tube in which the deflection coils are driven by transistors.

Transistor Diodes

A REVIEW of some characteristics of four-layer transistor diodes was given by Dr. W. B. Shockley in his address at the opening session of the International Convention on Transistors and Associated Semiconductor Devices (see our May 22 issue, page 796). These diodes are based on principles of internal control action in place of the external control required for conventional transistors. Because of this simplification, transistor diodes require only two external connections instead of the three used by transistors. Dr. Shockley said the four-layer transistor diode, now in its second year of commercial production, was finding many applications, including an outstanding performance in a new high-speed digital computer which took approximately one-millionth of a second to extract any of 80,000 bits of information from magnetic memory cores. Recent experiments indicated that within two to three years transistor diodes would attain power levels 10 to 100 times higher than related transistors with comparable frequencies and efficiencies.

Calculations had shown, he said, that four-layer transistor diodes used in class C oscillator and amplifier circuits could be operated at high power levels over junction areas much larger than were possible in transistors. To obtain this uniform operation over large areas, two new operating principles were employed. The first was impulsive charging, by which the interior base layers were uniformly flooded over their entire areas with electrons which turned the diode on like a switch. The second was majority carrier extraction, which removed the added electrons and also some normally present. This turned the diode off like opening a switch and prepared it for impulsive charging.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

TRANSPORTABLE STEAM-DRIVEN POWER SET

SIR,—Following your published details of the Steam Power Unit, we were interested to read Mr. Pollard's comments on the subject of safety in your issue of May 8; and whereas we readily agree that steam raising is always attendant with certain dangers, metallurgical, structural and design techniques have for all practical purposes removed the hazards of explosion. Control flow and monotube steam generators are acknowledged to be relatively safe, and in stating that explosion is virtually eliminated we are reiterating an accepted fact. We consider that quantity of water is relevant, and a shell boiler of equal output could conceivably have a capacity of approximately 60 gallons or thereabouts. Mr. Pollard is doubtless well acquainted with the equivalent explosive forces of a cubic foot of water at 100 lb pressure.

Concluding, we agree with Mr. Pollard that it is unwise to minimise the risk of improper operation, but we nevertheless consider that when equipment is designed to withstand abuse and rough usage, these facts can be publicised with justification.

P. L. FEWKES,
Director and Sales Manager.
E. Reader and Sons, Ltd.,
Nottingham, England,
May 15, 1959.

SIR,—I was interested to read the letter from Mr. J. G. Pollard in your issue of May 8 referring to the claim made of the virtual elimination of explosion in the boiler employed. Speaking with considerable experience of small monotube steam generators as fitted in White and Serpollet steam cars I think that a claim of virtual elimination of explosion danger is a fair one. In my time I must have had some ten cases of tube failure due to overheating under pressures of anything up to 600 lb per square inch with a bang comparable to a tyre burst, and nothing else.

The absence of danger from this class of steam generator is confirmed by the fact that the steam car fitted with a monotube generator is accepted by all the insurance companies whereas it is well-nigh impossible to get multi-tubular boilers of the type fitted to the Stanley steam car accepted. The fact that the water content of a monotube generator is distributed over a considerable length of solid drawn steel tubing means that a split anywhere results in the escape of steam and water more on the lines of the lifting of a "Pop" safety valve than an explosion.

The concluding sentence of Mr. Pollard's letter contains a wise suggestion relative to operation by unskilled labour. I would, however, say without the slightest hesitation that no other steam generator can stand abuse to the extent that the monotube will or cause less danger to the operator should tube failure occur.

KYRLE W. WILLANS
Devizes,
Wiltshire,
May 19, 1959.

ROAD SAFETY

SIR,—What is the use of any talk about road safety so long as the motoring industry and motoring writers continue to glamourise "performance." Most cars to-day have more performance than can safely be used. The young are very impressionable about these matters (and some older ones who ought to know better). The game of jockeying for position, bursting from the touchline on the amber, and overtaking, will go on until a new spirit is born or some pretty stiff regulations enforced.

H. E. CLARK
Crawley Down,
Sussex,
May 21, 1959.

Book Reviews

Anton Philips of Eindhoven. By P. J. BOUMAN. Weidenfeld and Nicolson, 7, Cork Street London, W.1. Price 30s.

Anton Philips of Eindhoven is a well-handled book of surprising interest to the general reader. The flow of the narrative is sometimes marred by the obvious effect of translation and is frequently interrupted by footnotes which could have been interpolated in the text. The weakest chapter of the book is undoubtedly that on travel, which comprises little more than a catalogue of the places visited by Mr. and Mrs. Philips in the later years of his life. Apart from these minor de-merits the book is readable and sincere. The history of the Philips enterprise is traced from its small beginnings in 1891 to the world-wide organisation it had become by the time of its Sixtieth Jubilee in 1951, the year of Anton Philips' death at the age of seventy-seven.

There is no fairy-story sentiment in this biography, which clearly shows how the success of the Philips concern, first as a family business and later as a public company under the same virtual "one man control," developed on the basis of Gerard Philips' technical genius and Anton Philips' superb ability to sell and to take long-term, calculated risks.

The text is interspersed with anecdotes intended to give to the reader some insight into the personal character of its subject. They tend, however, to convey the impression of a somewhat pompous nature, which was, in fact, no part of Anton Philips' make-up. He had, in common with many of his countrymen, an extraordinarily deep feeling for the home and family, whereas in office and works he was an odd and slightly unpredictable mixture of ruthlessness, kindliness, aloofness and friendliness. He was, above all, a leader of men and he inspired a firm loyalty from the vast majority of his colleagues and workpeople.

In so far as the life of Anton Philips was bound up with the Philips organisation in Eindhoven, as it was to an enormous extent, the story is very much summarised, since a detailed exposition of the expansion of N.V. Philips' Gloielampenfabrieken would fill many volumes. The biographer manages to portray, however, the impact of Anton Philips' personality on the employees of the Philips organisation. Philips so obviously had their welfare at heart, and the improvements which he and his wife made in their working conditions were forerunners of the sociological improvements which are now accepted as a matter of course in most developed countries. Probably the most outstanding innovation in this sphere was Philips' insistence that all his workpeople should be subjected to X-ray examination. In this he was, without doubt, the first industrialist to use what is to-day known as mass radiography. Philips instituted this practice as long ago as 1932.

This book is the genuine success story of a man who achieved greatness by his own acumen.

Nuclear Reactor Shielding. By J. R. HARRISON, M.A. Temple Press, Ltd., Bowling Green Lane, London, E.C.1. Price 10s. 6d.

THIS book is the fourth in a series of monographs on specific aspects of nuclear engineering. It is intended to provide an introduction to the principles and practice of reactor shielding. The book begins by defining the requirements of reactor shielding, taking account of the concepts of maximum economy and (for mobile systems) minimum weight. Gamma radiation and its attenuation in various materials are then considered. There follows a chapter on neutron physics, in which the author considers neutron sources and interactions with shield materials and discusses three methods of analysis which have some applications in shielding problems—namely, diffusion theory, age theory and removal theory. The application of these theories to the practical problems of shielding are then dealt with. A final chapter touches upon miscellaneous matters such as neutron streaming along ducts and coolant activation.

Books Received

Philosophy of Structures. By E. Torroja. Cambridge University Press, Bentley House, 200, Euston Road, London, N.W.1. Price 94s.

Patents for Engineers. By L. H. Carr and J. C. Wood. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 18s.

Modern Foundry Practice. Third edition. Edited by E. D. Howard. Odhams Press, Ltd., 96, Long Acre, London, W.C.2. Price 30s.

Chemical Engineering Group Proceedings. Vol. XXXVIII, 1956–57. Chemical Engineering Group, 14, Belgrave Square, London, S.W.1.

Advanced Mechanics of Fluids. Edited by H. Rouse. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 78s.

The Directory of Shipowners, Shipbuilders and Marine Engineers, 1959. Tothill Press, Ltd., 33, Tothill Street, London, S.W.1. Price 40s.

Jets and Rockets. By A. Barker, T. R. F. Nonweiler and R. Smelt. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 35s.

Handbuch Der Werften, 1958. Edited by K. Wendel. Schiffahrts-Verlag "Hansa" C. Schroedter and Co., Hamburg 11, Stubbenhuk 10, German Federal Republic. Price DM.36.

SHORTER REPORTS

Bridge for Mono-Rail Transporter

THE mono-rail transporter made by Road Machines (Drayton), Ltd., has been widely used on building sites since its introduction about ten years ago. Since that time, and since our description of it in THE ENGINEER of December 9, 1949, several improvements have been introduced to the system, the most recent of which is a mobile bridge which, although originally conceived simply to span an area of the constructional site, is intended also as a distributor and spreader.

The accompanying illustration shows the powered wagon of a mono-rail train passing over the mobile bridge. Normally, mono-rail rails are set up on either side of the area to be concreted, accurately parallel to each other. The width of the bridge is 24ft ; extension pieces, each of 6ft, can increase it to a maximum of 36ft. On the 24ft bridge are mounted curved rails of 24ft diameter, which gives an arc of travel of 180 deg. (with spans greater than 24ft, straight rails are inserted). To each end of the curved section is fitted a special rail—the " take off " rail—which serves as a ramp from the track rails to the curves. Thus the mono-rail power wagon runs on the track rails until it meets the ramp or " take off " rail which it climbs and then traverses the bridge.

The whole bridge is mounted on four roller bearing wheels which run on the mono-rail track, and it can be easily moved by two men. Thus concrete from the wagons can be discharged at exactly the right spot throughout the complete length of the bay. The illustration clearly shows the " take-off " rail, and also shows the timber spreader bar carried below and behind the bridge, which strikes-off the top level of the concrete as the bridge is traversed. This particular illustration shows concreting of the Cavendish Way bridge, for Hatfield Development Corporation (consultants Messrs. Rendel, Palmer and Tritton ; contractor W. and C. French, Ltd.). The rail stands are carried on 12in by 12in timbers spanning the railway, and a complete, U-shaped track circuit is in use to place concrete in the heavily-reinforced bridge slab. The mixing station is 300 yards away at ground level, and concrete is taken by dumper to the mono-rail wagons at the high level.

The mobile bridge of tubular steel shown here is supported on rollers on the parallel " mono-rail " rails. It is translated across the bay as concreting proceeds, so that the mono-rail wagons discharge expeditiously throughout the work

Anglo-German Collaboration in Nuclear Power

A LONG-TERM nuclear power agreement has been made between The General Electric Company, Ltd., of England, and Maschinenfabrik Augsburg-Nürnberg A.G. (M.A.N.), of Germany. The agreement, which is initially for a period of ten years, but is capable of extension, was signed on Monday, May 25, at Nuremberg by Mr. Arnold Lindley (assistant managing director) and Mr. R. N. Millar (director) for the G.E.C., and by Herr Ulrich Neumann (director-general) and Herr Hans Fischer (director) on behalf of M.A.N. Commenting on the agreement, Mr. Lindley said that it underlined the value of British experience with the graphite-moderated, gas-cooled type of reactor. Recent developments had shown that, with further research, this system was capable of much greater versatility than was originally envisaged. He was confident that this co-operation between the two companies would make an important contribution towards meeting Europe's future power requirements.

Under the terms of the agreement, M.A.N. will pay the G.E.C. a capital sum plus a service fee per kilowatt of guaranteed electrical output from nuclear power stations ordered from M.A.N. The German company will be granted licences for all G.E.C. nuclear patents. These rights will be exclusive in the Federal Republic of Germany, and non-exclusive for the rest of the world with the exception of the British Isles and of those Far Eastern territories already covered by G.E.C.'s previous agreement with the First Atomic Power Industrial Group of Companies in Japan. Similarly, any inventions which M.A.N. may make relating to nuclear power plant will be available to the G.E.C. organisation.

The new agreement, however, is much more than a licensing arrangement. The whole of the knowledge and experience accumulated by G.E.C., and by her British collaborator Simon-Carves, Ltd., in the design and construction of nuclear power plant, will be made available to the German company. Tangible evidence of the extent of this " know-how " is to be found in the Hunterston power station in Scotland, already at an advanced stage of construction, and in the fact that G.E.C. has recently been chosen to build Japan's first nuclear station. The agreement with M.A.N. relates to all kinds of nuclear power plant based on the gas-cooled, graphite-moderated reactor, including ship-propulsion applications.

The traffic in knowledge and facilities will not, of course, be one-way. M.A.N. has large factories in Augsburg, Nuremberg, Gustavsburg, Munich and Hamburg : its products include boiler plant, steam turbines, diesel engines, pumps, handling plant, bridges and structural steelwork ; the German company's wide experience in heavy steel fabrication is of special interest in the present context. M.A.N. has already been concerned with mechanical engineering aspects of research reactor projects in Germany.

During the first stage of the agreement, G.E.C. will normally act as main contractor for all nuclear orders received. The ultimate aim, however, is that M.A.N. shall itself become competent to prepare tenders and to execute complete contracts to designs resulting from the collaboration. To this end, G.E.C. staff will advise and assist the German organisation in setting up the necessary facilities, while M.A.N. key personnel will receive special training in the United Kingdom to equip them for full participation in this rapidly developing field of technology.

Stephenson Locomotive Society Golden Jubilee Tour

THIS year is the Golden Jubilee of the Stephenson Locomotive Society, which was formed as the Stephenson Society on December 11, 1909. The inception of the idea which led to its formation may be traced back to an earlier meeting, on June 27, 1899, at which a group of railway enthusiasts met in Birmingham to discuss the formation of a society catering for their interests. This gathering of sixty years ago led to the inception of the Railway Club, two early members of which—L. E. Brailsford and G. F. Burtt—later organised the setting up of the Stephenson Society (the name of which was changed to " Stephenson Locomotive Society " on January 17, 1911). An event of the Society's Golden Jubilee year, therefore, has been a London–Doncaster tour arranged on a date coinciding closely with the sixtieth anniversary of the Birmingham meeting—the first important expression of organised railway interest among amateurs in this country. The tour took place last Saturday, May 23, and on the outward journey from King's Cross followed part of the original main line of the Great Northern Railway by approaching Doncaster via Lincoln and Gainsborough.

Some 400 members and guests from other organisations travelled in the eight-coach special train, which was hauled in both directions by the Eastern Region " A4 " class " Pacific " locomotive No. 60007, " Sir Nigel Gresley." On the outward run a speed of 102 m.p.h. was attained between Hitchin and Huntingdon, and on the return journey, made throughout over the present main line via Retford and Newark, the train reached a maximum of 112 m.p.h. while descending the bank near Essendine. The locomotive was in charge of Driver W. Hoole.

The Stephenson Locomotive Society to-day numbers over 2000 members, and has twelve centres in different parts of the country. Its history has an association with the Institution of Locomotive Engineers in that the latter was founded by former S.L.S. members who wished to develop a society along professional lines.

Completion of Tunnelling Scheme on the Great Northern Line

THE Eastern Region's £3,000,000 scheme for quadrupling the main line into King's Cross at Potters Bar and Hadley Wood has now been completed, and was inaugurated on May 20 by Sir Brian Robertson, who unveiled a plaque at Hadley Wood station. The entire scheme has consisted of constructing two new tracks over a distance of 2½ miles and installing colour light signalling and track circuiting over the reconstructed length; constructional work has involved driving three new double-track tunnels totalling over 1800 yards in length, reconstructing Potters Bar and Hadley Wood stations, excavating the remaining lengths to the track level, and building small retaining walls of concrete and steel sheet piling. As a result there are now at least four tracks from King's Cross for 21 miles, to the viaduct at Welwyn, where there is still a 2-mile section with only two tracks.

The principal engineering interest in the scheme lies in the use of unbolted precast concrete segments in the lining of the tunnels. These are, in fact, the first railway tunnels to be driven through clay in this country since just before the first world war, and they are, apparently, the only ones in which this method of lining has been used. We have already described the construction of these tunnels in THE ENGINEER of February 14, 1958 and April 19, 1957 (and also the new station at Potters Bar, in our issue of December 2, 1955) so only a very brief account of this one aspect of the scheme is given here, and we refer readers to our earlier articles for more complete details.

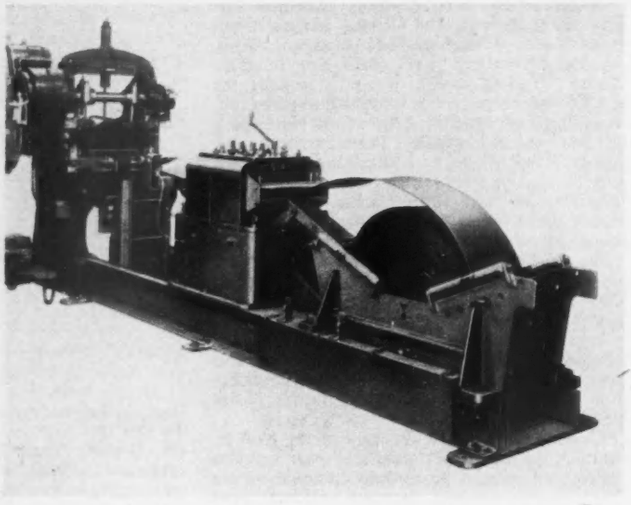
The internal diameter of each tunnel is 26ft 6in. The interlocking concrete segments were placed in the tunnel pressing against the clay. No grouting or bolting was used. The lining was erected in rings 18in wide to produce the same result as a bolted cast iron ring. Each ring consists of a reinforced invert (weighing about 4½ tons), with three interlocking segments on either side, forming the lower half of the ring. The upper half of the ring is formed of thirteen segments. The shield was pushed forward by rams bearing against the last completed ring of lining, to allow the next ring to be assembled immediately behind the shield. The units of the ring were then forced apart by jacks set in slots between pairs of the segments in the waist at each side of the tunnel. The jacks were subsequently replaced by a very dry concrete pinning, introduced in two stages so as to avoid release of the load on the ring. The segments of the ring are interlocked with each other and each ring is interlocked with the next by recesses and ribs on the faces of adjacent segments. The cost of a tunnel lined in this way is claimed to be 40 per cent less than for lining throughout with conventional cast iron segments.

The consulting engineers for the tunnelling were Sir William Halcrow and Partners, the rest of the scheme being under the charge of the chief civil engineer of the Eastern Region, Mr. A. K. Terris. The main contractor was Charles Brand and Son, Ltd.; track-laying was subcontracted to Henry Boot and Sons, Ltd., and Hadley Wood station was rebuilt by Kyle, Stewart (Contractors), Ltd. The electrical work was under the direction of the Eastern Region's chief mechanical and electrical engineer, Mr. K. J. Cook, and the signalling work was carried out by Metropolitan-Vickers–G.R.S., Ltd., as main contractor under the supervision of Mr. R. A. Green, the region's signal engineer.

Coil Cutting and Straightening Line

WE illustrate an equipment supplied by Press Equipment, Ltd., Hunters Vale, Birmingham, 19, for automatically uncoiling, straightening and cutting to length material from coils up to 36in wide. This typical equipment has a capacity for handling 15in wide by 0·104in thick mild steel from 48in diameter coils weighing 2 tons. It is built to measure and cut any required length of steel, its usual operating range being from 6in to 6ft lengths.

As can be seen the equipment comprises essentially a coil cradle, a roller straightener, and a shear mounted in line. The coil cradle, which is driven from the straightener to ensure synchronisation, has side plates and rollers adjustable for coil width. Motor drive to the straightening and feeding head is transmitted through an electro-magnetic clutch and variable speed unit and a worm reduction gearbox. A crank handle is used for setting the pinch rolls and straightening rolls to the required pressure and material gauge.



Automatic uncoiling, straightening and shearing-to-length line for coiled material

A handwheel control sets the speed of the line to coincide with any following operation on the strip lengths, and if required the machine performing this operation can govern the whole line. The material is measured and held until sheared, when it is released to fall on to a gravity or powered conveyor to the next operation.

Although a coil cradle is embodied in the line illustrated the makers point out that coil reels may be employed for holding thin gauge or non-ferrous materials. The type of shear used depends upon the application, and if required, existing shears can be built into a line.

Front Loading Shovel

A MECHANICAL shovel with a 1 cubic yard capacity bucket, now being made by Merton Engineering Company, Ltd., Faggs Road, Feltham, Middlesex, has the cab at the front so that the driver has a completely unobstructed view of the bucket and the ground to his front. The cab, of heavy gauge steel sheet with large toughened glass windows, is so made that the whole rear section slides backwards to give access from either side of the machine.

The "Frontloader," as it is known, is fitted with a Fordson tractor unit, and its hydraulic linkage gives a loading height (under the lip of the tipped bucket) of 10ft 6in or 12ft under the hinge pin. At this maximum discharge height there is a forward reach of 2ft. The standard 1 cubic yard bucket covers the full width over the front wheels and has a payload of 2800 lb, smaller or larger capacity buckets being also available for very heavy or light materials. The bucket crowd angle is 45 deg. and its discharge angle at maximum height is 45 deg.

A heavy duty Marles cam and double roller steering gear gives the machine a turning circle of only 33ft and a fully oscillating front axle is fitted. Power from the Fordson four cylinder, 54 b.h.p. at 1800 r.p.m. engine is transmitted to the rear wheels through a 13in Borg and Beck heavy duty clutch and the machine has six forward and two reverse speeds, up to 12·45 and 4·75 m.p.h. respectively.

1 cubic yard bucket front loading mechanical shovel

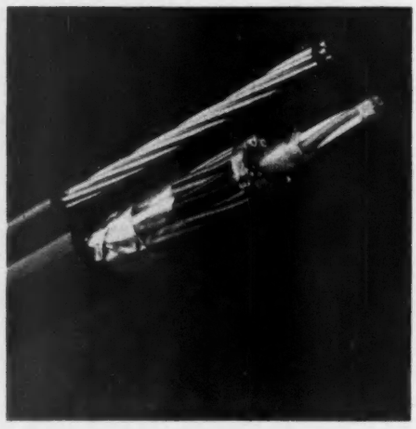
In addition to the range of buckets, other equipments which can be fitted to the "Frontloader" include a bulldozer blade and crane and fork lift attachments. Also available is a Holman two-tool compressor unit which can be fitted within the wheelbase beneath the rear canopy.

Self-Supporting Telephone Line

A SELF-SUPPORTING overhead telephone line with cable and suspension strand integrally sheathed was commissioned on the Ramsgate–Canterbury section of the Southern Region, British Railways, Kent Coast electrification on May 1. This cable, which has been supplied, erected and jointed by Siemens Edison Swan, Ltd., is new to British Railways, and replaces existing open-wire lines on part of the Southern Region's own telephone system. The design is often referred to as "cottage loaf" because of its characteristic cross section (seen in the illustration).

Three sizes of cable are used: sixteen-pair, twenty-pair and twenty-eight-pair. The 0·050in, 40 lb per mile conductors are polythene-insulated and laid up in star quad formation, the requisite number of quads being stranded together and a screening applied overall. The cable and suspension strand are integral in the overall p.v.c. sheath. Some of the cable pairs are loaded at 2000-yard intervals in order to maintain the signal at a level such that these pairs can form part of a circuit much longer than that of the Ramsgate–Canterbury section itself.

Another contract being carried out by the company on the Southern Region is the supply and laying of two paper-insulated, lead-alloy-sheathed, quad-trunk telephone cables, one of fifty-four and the other of fourteen pairs. They employ p.v.c. sheaths both over the lead and over the armour, for special protection against electrolysis and corrosion. These cables are laid in concrete troughing over a 5-mile length.



Telephone line with suspension strand and cable pairs integrally sheathed in p.v.c.

"Civils" Dinner

SOME interesting points were made by speakers at the Institution of Civil Engineers' annual dinner, which was held at the Dorchester Hotel on May 21. Sir Edward Appleton, proposing the toast "The Institution," expressed his appreciation of being elected to honorary membership of an institution "concerned to employ specialised learning in professional service of the highest possible standing." "While I remain a convinced champion of specialisation," he said, "I should be ready to see some studies in the sciences deferred to the post-graduate stage in order to leave room for more humanistic studies during the undergraduate career of the scientist and engineer.

"Minute linguistic studies of dead or living languages just will not do in this connection. The young scientist gets his mental disciplines in another way. While he is at school, the budding scientist and engineer should link his humane and scientific studies by way of history, but history taught the right way, not as an additive catalogue of facts, but as a delineation and analysis of human experience, history in which science falls naturally into its place as part of man's intellectual and social development. For the more mature student at the university, the link between the sciences and the humanities can be further emphasised by mental philosophy and moral philosophy and the social sciences."

The president, Professor A. J. S. Pippard, responded to Sir Edward's toast, and said that in his presidential address last November he had expressed the opinion that more collaboration between the various engineering institutions and branches of engineering would be necessary to enable the engineer to take his proper place in the scheme of things and to carry out the great works of construction which were springing up all over the country. The existence of a number of institutions all working towards the same ends was no longer a source of strength, he asserted, but could be unsatisfactory; it must detract from the influence which the engineer could bring to bear upon the conduct of affairs.

There was a very close liaison between the Institution of Civil Engineers, the Institution of Mechanical Engineers and the Institution of Electrical Engineers, the professor explained, and he believed that that would be increasingly effective as time went on. He hoped that that association would be extended to certain other bodies. But there were too many separate organisations working towards objectives which could be reached much more readily if it were done by a unified profession. In the past the idea of amalgamation to achieve that unity had aroused fears that standards and traditions would be lost, but there was now a realisation that amalgamation need not be inconsistent with the wholly proper aspirations of the contracting parties.

"Discussions between ourselves and another very important body, the Institution of Municipal Engineers, have been going on for some time," he said, "and they have now reached a stage when certain proposals will be put to the councils of the two Institutions. I hope very strongly that an agreement can be reached to the mutual advantage of both Institutions, and that such an amalgamation may prove a pattern for other societies which are closely allied to us in achieving the aim of our Charter. I think that can be done without sacrificing—indeed, it can be done by incorporating—the great traditions created not only by ourselves, but by other bodies."

On the subject of professional education, Professor Pippard pointed out that three-quarters of those presenting themselves for "professional interview" had received a university education and held a university degree or its equivalent. That was a high proportion in any profession, and it meant that the general practitioner was expected to hold the qualification of a first degree! At present 25 per cent of would-be entrants, he went on, had not received what was generally accepted as the best qualification for professional practice. That was partly due to the regulations governing the award of state scholarships in that the amount payable was dependent on the income of the parent; the Civil Engineering Scholarship Trust, however, had awarded ten scholarships last year, and it was hoped shortly to award another dozen or so scholarships. When the scheme was fully in operation between thirty and forty young men would always be in training in the universities. There was also a scheme, the professor noted, for young men to sign for four years—instead of two—with a firm of consulting engineers or contractors and to spend a year of this on a post-graduate course after two years' practical training.

The toast of "The Guests" was proposed by Mr. A. C. Hartley, and Sir John Macpherson, permanent under-secretary of state, Colonial Office, replied.

Surveillance Radar at Test Airfield

ACCEPTANCE trials were completed recently of a new long-range surveillance radar installation at the Wisley airfield (near Weybridge, Surrey) of Vickers-Armstrongs (Aircraft), Ltd. The equipment is a Decca "MR 100" radar supplied by Decca Radar, Ltd., Albert Embankment, London, S.E.11, and represents the trend towards 10cm installations for civil terminal air surveillance which this company is pursuing. The "MR 100" is, in fact, a version to meet the specific requirements at Wisley of the new series of D.A.S.R.1 radars recently developed by Decca for general civil application.

For some years Wisley has been fitted with Decca 424 approach radar. The situation of the airfield, close to the London civil aircraft control zone and to the Farnborough approach pattern, makes it necessary for the controllers to have an overall picture of the general traffic pattern in the area. To achieve this the displays from the approach radar and the new surveillance radar have been centralised in the control tower operations room.

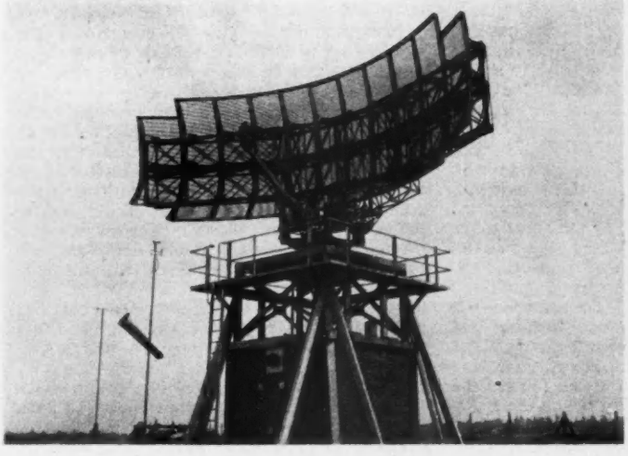
The Decca "MR 100" is a long-range terminal surveillance radar operating in the 10cm band. A high-gain aerial fed with a power of 750kW provides the performance necessary for control of all aircraft, including large and small jets, operating from Wisley out to 100 miles on a small fighter target and to more than 150 miles on larger aircraft, the corresponding heights being 40,000ft and 50,000ft. Coverage is free from gaps over the whole height and range of operation. A high rate of information renewal (10 r.p.m. aerial rotation) is adopted, and there is high discrimination in the radar picture both for identification and control at long range and for feeding approaching aircraft into the local airfield radar pattern.

The site selected for the aerial installation is adjacent to the control tower and gives little primary permanent echo clutter. In any case, a special aerial reflector with very sharp cut-off on the lower edge of the beam provides a close-in performance right through the clutter area which has made it possible to carry out P.P.I. approaches to within 1 mile of touchdown.

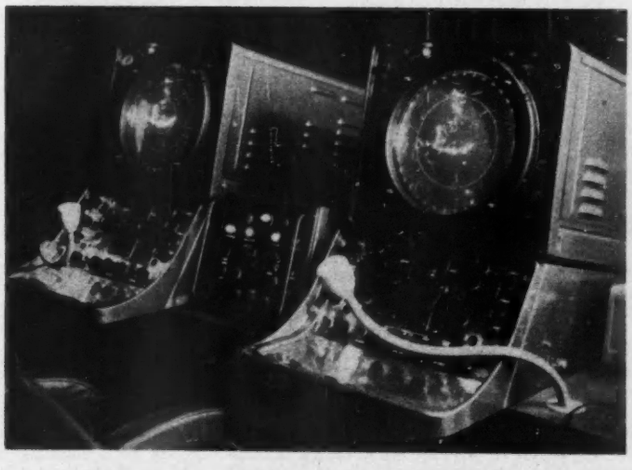
The aerial is of 33ft horizontal aperture, producing a beam width of 0·65 deg. at half-power points. The vertical beamwidth is 3 deg. nominal, with high-angle coverage up to 20 deg. Transmitter pulse length is 1·5 microseconds and the pulse recurrence frequency 350 per second.

The receiver, switchable to linear or logarithmic characteristics, is fitted with automatic frequency control to within ±200 kilocycles and incorporates the usual swept gain and short time constant adjustments for picture control. It operates two fixed-coil displays, with four range scales available between 0 to 10 nautical miles and 0 to 180 nautical miles, the shorter ranges have facilities for off-centring along one radius. An interscan range and bearing strobe is provided for making measurements between any two points on the P.P.I. As the origin of this variable electronic line can be off-centred to airfields other than Wisley, it provides a rapid and simple method of determining course and distance to any airfield. In these circumstances the strobe line shows the track the aircraft must follow and its progress along it can be checked. When the strobe has been set between the two points required, range and bearing of one from the other are read off directly in a window below the P.P.I. tube. In the Wisley installation reciprocal bearings are given so that they may be used at once as the basis of a course to fly.

Experience during the trial period showed that airliners approaching London were normally detected over the coast of France or as far inland as Birmingham and Bristol. There was thus a comprehensive overall picture available so that the test flying of "Vanguards," "Viscounts" and military aircraft could be controlled and directed safely in this very busy area, enabling a considerably higher number of useful flying hours to be achieved.



Aerial system at Wisley, with reflector designed for sharp cut-off to reduce clutter



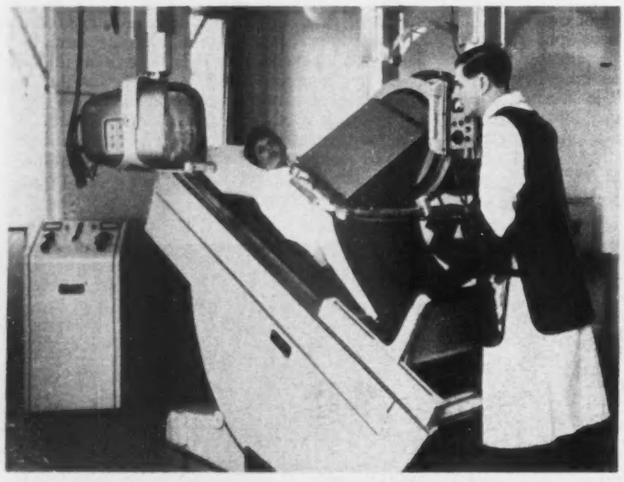
Display units and control panels. The "windows" below the P.P.I. tubes present range and bearing information derived from the interscan strobes

X-Ray Image Amplifier

USING a 4½in image orthicon designed originally by the English Electric Valve Company, Ltd., for the B.B.C., Marconi Instruments, Ltd., St. Albans, has developed a new X-ray equipment by means of which 11in by 11in fluoroscopic images suitable for examination by normal lighting, are given on one or more monitor screens. After passage through the patient, the X-ray beam impinges on a fluorescent screen and the resultant image is reflected through 90 deg. by a mirror into a lens system, and then to the photo-cathode of the image orthicon camera tube. At this stage the picture is converted from light into electronic form, so that it can be amplified and reproduced on television style screens. A remote recording unit can also be connected to the electronic rack for making ciné or spot film records. Image amplification enables the X-ray dosage to the patient to be reduced, and during tests with this apparatus the exceptionally low dose-rate of 2mr/second has been used to view a thorax while maintaining an image of sufficient clarity for accurate diagnosis. Brilliance and contrast controls are provided on the monitor units and a high-definition is obtained by a one-thousand-line, triple-interlace system. Positive or negative image polarity is selected by a switch on the control unit.

Further and still more noteworthy reductions in dosage will be attained with an additional unit which the company plans to make available in the near future. This will use a storage technique to retain an image which may be formed on its screen with an exposure as short as 0·08 second. By using a slow repetition rate, a stroboscopic view of moving body parts is obtainable. It is hoped that eventually it will be possible to put a picture on the screen in 0·02 second.

Apart from the convenience of enabling images to be viewed on several tubes simultaneously in different locations, the independent viewing monitor arrangement allows the operator's screen to be mounted in a position chosen to ensure a clear view while leaving his movements unobstructed. This is evident in the accompanying illustration, which also shows how the arrangement of the pick-up unit at right angles to the table enables him to work close to the patient at all angles. The saving of space by this construction is particularly advantageous when the table is set vertically. It also simplifies installation by reducing the clearances required. At the same time the arrangement prevents the orthicon from assuming angles below the horizontal at which its operation and life would be impaired. At a recent demonstration it was stated that only about 8 per cent of the light is lost by the reflector system.



Pick-up camera, viewing monitor and control unit of 12in image amplifier installation. Mounting the camera unit at right-angles to the patient reduces the clearances required for tilting and gives the operator an unobstructed field for work and inspection at all angles of the table

In the near future, a development prototype of the image amplifier will be installed in the Department of Neurological Surgery of St. Bartholomew's Hospital, at Hill End, St. Albans, to obtain operating experience in both radiological and electronic fields. The company plans to make six equipments this year, the first of which will be exhibited at the Ninth International Congress of Radiology in Munich in July. At present the resources of the team which has developed the apparatus are fully absorbed by the prospective medical demand, but the possibilities of industrial applications of fluoroscopy with the image amplifier are being kept in view.

Microwave Oscillator with Electrostatic Focusing

A COMPACT microwave generator embodying a new focusing principle has been developed at the Wembley research laboratories of The General Electric Company, Ltd. The programme of research which has led to this type of valve was carried out by the G.E.C. for the Admiralty, under the programme for co-ordination of valve research and development. The valve, an electrostatically-focused backward-wave oscillator, has been named the "Ophitron," from the Greek word for a serpent, the name being suggested by the undulating path of the electron stream flowing along the structure. In the passage of the beam through the internal structure of the valve, an r.f. wave is propagated containing harmonics which interact with the wave to set up oscillations. The output of the oscillator is coupled to a waveguide by means of the probe seen in the illustration on the side of the envelope. The probe mounting enables the valve to be connected direct to an X-band waveguide.

"Ophitron" microwave oscillator. The valve is 6in long, ¾in in diameter and weighs 7 oz

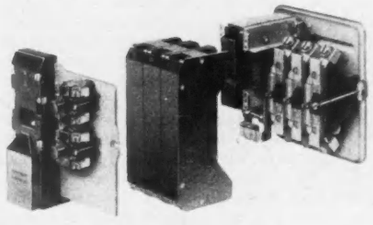
In the "Ophitron" a single stamped-out periodic structure and two flat focusing plates form the propagating path for the r.f. wave, and set up the electrostatic field which focuses the undulating electron beam so that its crests are brought into the region of maximum r.f. field, giving good coupling between beam and wave, and leading to greater bandwidth than is obtained with the equivalent magnetically-focused backward-wave oscillator. The present "Ophitron" tunes electronically over at least a 40 per cent band in the 10,000 Mc/s region, and is suitable for applications such as local mixer oscillators in receivers and test equipment oscillators. A range of such valves is envisaged, covering most important centimetre wavelength bands. It is expected that the noise performance will be better than that of magnetically-focused backward-wave oscillators because of the ion drainage from the electron beam inherent in the focusing method.

It will be manufactured and sold by the M.O. Valve Company, Ltd., Hammersmith, a wholly-owned subsidiary of The General Electric Company, Ltd., Kingsway, London, W.C.2.

Heavy-Duty Contactor-Starters

A NEW series of heavy-duty contactor-starters, known as type J–60, has been introduced by J. A. Crabtree and Co., Ltd., Lincoln Works, Walsall, Staffs. These starters comply with British Standards 587 and 775. Minimum mechanical life is stated to be 5,000,000 operations. This new range of contactors and contactor-starters is an early product of the development and test facilities which have been available to the company on its own premises since completion of the short-circuit testing station described in our September 19, 1958 issue, page 461.

When used as a contactor on a.c. supplies of 415V, 50 c/s, the type J–60 has a rating of 100A per phase for heating loads and 60A per phase for inductive loads. On the standard 415V supply the direct-on starters are suitable for motors of up to 40 h.p. and the automatic star-delta starters for motors of up to 70 h.p. In common with all the company's control gear, the range has been developed from a small number of standardised and interchangeable units which are mounted on single or two-unit backplates to suit the facilities required. The same backplates will accommodate built-in isolating switches and h.r.c. fuses.



Components of contactor unit, showing horizontal-closing main contacts

Single-unit cast aluminium cases are employed for direct-on contactors and starters and for separate isolating switches with or without fuses. Two-unit cases are used for direct-on starters with isolating switches and for reversing starters without isolating switches. Sheet steel cases are supplied for assemblies consisting of more than two units—such as star-delta starters, reversing starters with isolating switches, or pole-changing starters. All enclosures are provided with gasketed covers or doors. Features of the design include the magnet system, which operates vertically, the motion being translated through 90 deg. to give horizontal closing of the main contacts. Nylon buffers are provided to absorb the shock of magnet closure. The moving contacts embody a patented damping device designed to ensure bounce duration of less than one millisecond.

The compensated thermal three-phase overload unit is operated by current transformer. It is available in two sizes, 15A to 30A, and 30A to 60A, and is adjustable on site for hand or automatic reset. The triple-pole, double-break isolating switch has a continuous rating of 100A per phase, but is capable of making and breaking currents up to 800A at 440V. Two auxiliary poles are available for currents of up to 5A at 440V. The operating handle is mechanically interlocked with the starter cover or door.

New Counter Tubes

A NEW cold cathode counter tube introduced by Mullard, Ltd., Mullard House, Torrington Place, London, W.1, is designed to permit cascade-coupling of a complete counter chain without interstage amplifiers. The tube, Z302C, consists of a circular anode surrounded by thirty rod cathodes which are connected to form ten repeated groups of three electrodes. In each group (going clockwise) is a guide cathode, an extinguish cathode, and a main cathode. The display is given in the usual manner by a glow discharge which is moved from one main cathode to the next by the input pulses which are being counted. On receipt of the tenth pulse, however, the circuit arrangements are such that the anode potential drop is some four times that which occurs in the normal transfer process. The output pulse so produced is sufficient to overcome the positive bias applied to the guide cathodes of the next counter tube by connection of a high-value resistor between them and earth. Consequently the discharge of the next tube begins stepping, and on reaching its final position will trigger the next tube of the chain in the same manner. With suitable circuit development, it is expected that this tube will count reliably at speeds up to 1000 pulses per second.

A further addition to Mullard counters is the ET51 trochotron high-speed decimal stepping tube, for use as a counter or selector at speeds up to 1 Mc/s. The tube is switched by a negative signal and provides a constant-current output of 5·5mA, sufficient to drive a cold cathode decimal indicator and compatible with the input requirements of direct read-out digital indicators. Principal applications will be in nucleonic scalers, decimal computing equipment, and

High-speed trochotron, operating with crossed fields formed by the electron beam and the external cylindrical permanent magnet near top of envelope

electronic switching circuits, where it is stated that one ET51, with its relatively simple circuitry, can replace a number of conventional valves or transistors and their associated components.

The trochotron is a vacuum device which makes use of crossed electric and magnetic fields to form a beam of electrons between a thermionic cathode and any of ten groups of three electrodes mounted radially about the cathode. The electric field is provided by the inter-electrode potentials within the tube and the magnetic field by a cylindrical permanent magnet fitted externally around the glass envelope as seen in the illustration.

Each group of electrodes consists of a spade, which forms and locks the beam in position ; a target, which makes the beam available as a constant current output ; and a grid, for switching the beam from one spade to the next. When power is first applied, all spades will be equally positive with respect to cathode and, due to the action of the magnetic field in preventing electrons from reaching the electrode groups, the tube will be in a " cut-off " condition, with no beam formed. However, if the potential of any spade is reduced, by means of a high-speed pulse or a d.c. voltage, the beam will form on the electrode group associated with that spade, and an output will appear on the corresponding target.

Once formed, the beam is held in this position by a combination of the spade series resistance and spade current until it is stepped to the next position by lowering the voltage on the associated switching grid.

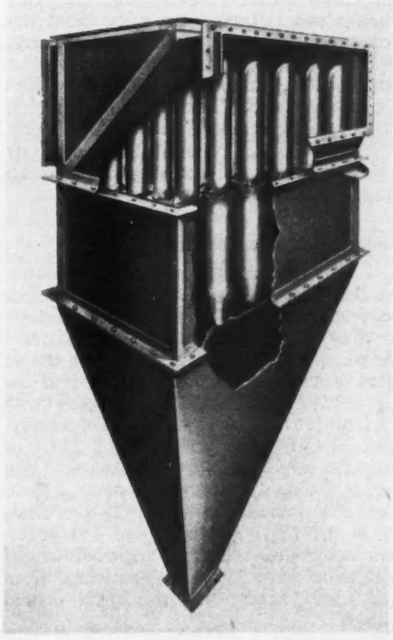
Since only the grid in its immediate vicinity will affect the beam, the grids are connected internally in two groups—the odd-numbered grids in one, the even-numbered in the other. This makes it possible to use a d.c. input for switching and still obtain single-position stepping, thus avoiding the necessity for a pulse of critical width.

The output characteristic of the trochotron is similar to that of a pentode valve, and in the ET51 over 80 per cent of the beam current appears in the output, the remainder being used to form and lock the beam. The tube is mounted on a special twenty-six pin (B26A) base comprising ten connections each for spades and targets, two grid connections, and heater and cathode connections. It has an overall seated height of 3·3in and an overall diameter of 1·74in including the magnet and special protective caps. The ET51 is a direct replacement for the American Services type 6700.

Dust Collection Plant

PARTICULARS have been received from Steels Engineering Installations, Ltd., Sunderland, of a new dust collector known as the " S.P.A.," now being manufactured under licence. It is of multi-cellular dry centrifugal design, but depends on a principle of selective particle acceleration. As can be seen from the illustrations on this page, the collector comprises a number of standard elements housed within a fabricated steel body with a dust collecting hopper. The number of elements is varied to meet the volume requirements of each application. No secondary system is used to effect final separation of the finer particles and no secondary booster fan is required. Separation of the entrained particles is carried out in one operation within the collector elements.

Each element comprises an inner and outer member assembled coaxially, the outer member being formed in two parts, comprising an operating zone and a cylindrical collector tube. The operating zone forms a funnel with rapidly decreasing cross-sectional area, the upper end being hexagonal in section and the lower end circular to match the cylindrical collector tube. The inner member comprises a straight length of mild steel tubing, passing centrally through the operating zone, coaxial with the collector tube and extending a little below the bottom of the operating zone. Within the annular space



Standard dust collecting elements mounted in fabricated steel housing

formed between the operating zone wall and the inner member are six guide vanes which are welded to the inside only.

Dust-laden air enters the element over its hexagonal face at low velocity, as shown in our second illustration. The guide vanes immediately

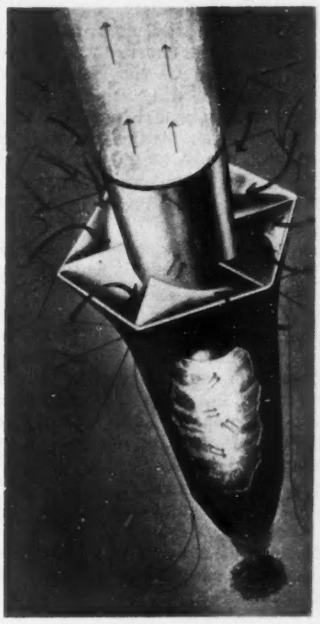


Diagram showing how the dust laden gas enters a collector element over the hexagonal face and is caused to rotate and accelerate by the vanes. The dust is centrifuged to the outside and the cleaned gas passes out through the inner element

deflect the air into a helical path and as it passes through the nozzle it is rapidly accelerated along this helical path by virtue of the decreasing cross-sectional area. The air emerges from the operating zone at a velocity of six times that at which it entered. It flows approximately two-thirds of the way down the collector tube in this helical path before reversing up the central core of the vortex to leave the element through the inner member. The separated dust flows down the walls of the open-ended collector tube, to be deposited in the hopper beneath. A straightening vane, placed inside the inner member, recovers some of the swirl energy and reduces frictional losses by restoring straight flow.

The manufacturers state that the patented feature of this design is the acceleration of the air as it passes through the operating zone on its helical path. This acceleration is very rapid, with the result that the larger particles, by virtue of their inertia, attain lower speeds than the small particles. As the different-sized particles are accelerated in their helical path (more or less rapidly in inverse ratio to their mass) they are acted on by increasing centrifugal force. When the centrifugal force acting on a particular particle is sufficient to overcome the viscous drag of the air in which it is immersed, the particle travels radially towards the wall of the operating zone, to be collected. Since the centrifugal force acting on the particle is proportional to its mass, which in turn is proportional to the cube of its diameter, and resistance to radial flow through the conveying air is proportional to the projected area, or diameter squared, it is apparent that lower velocities are required to effect separation of the larger particles. Conversely, by accelerating the dust-laden air, sufficient centrifugal force is established early in the acceleration to separate the large particles, leaving only the smaller ones to be accelerated to higher speeds to effect their separation.

The manufacturers claim for this design efficiencies of 80 per cent at 5 micron and 93 per cent at 10 micron, with dust having a specific gravity of two. It is stated that the power requirements of the collector are not high and at its normal rating, the resistance is 4in w.g. at 60 deg. Fah.

Industrial and Labour Notes

Anglo-Russian Trade

Last Sunday there was signed in Moscow a five-year trade agreement between the United Kingdom and Russia. It resulted from the activities of the British mission which has been visiting Russia under the leadership of Sir David Eccles, President of the Board of Trade. At the time of going to press, the full details of the agreement have not been made known ; their publication in the form of a White Paper is said to be imminent.

Meanwhile, it has been stated that, under the terms of the agreement, Russia will purchase from this country commercial vehicles, textiles and footwear, as well as capital equipment such as chemical plant, sugar refinery machinery and food-processing installations of various kinds. Proposed imports to this country from Russia include various machinery, some motor - cars, foodstuffs and matches, and an increase in present imports of grain, timber and minerals. A Russian delegation is to visit London shortly to negotiate detailed quotas as to trade in consumer goods and the Governments of both countries are to start talks, probably early next year, on a trade and navigation treaty.

Coal

Last week, the annual conference of the National Association of Colliery Managers was held at Harrogate. On the final day, May 22, the delegates were addressed by Sir James Bowman, chairman of the National Coal Board, who claimed that, over the last eighteen months, Britain's coal industry had "more than proved its resilience and capabilities." Colliery managers, Sir James said, had resolutely followed up in the coalfields the special measures which the Board had launched during that period and upon the success of which, he believed, would depend the direction and well-being of the industry for many years to come.

Sir James spoke also about present and future trends. Last year, he recalled, inland consumption of coal fell by 10,000,000 tons and exports by 3,000,000 tons : compared with 1956, total requirements were 20,000,000 tons lower. So far this year, in the first eighteen weeks, he continued, inland consumption had fallen by a further 6,500,000 tons and every major group of consumers had used less coal, although the drop was comparatively small so far as domestic consumers were concerned. By reducing opencast and deep-mined production respectively by 3,000,000 tons each in 1959, Sir James went on, the Board hoped to be able to limit further stocking to about 3,000,000 tons. But undistributed stocks had already risen steeply this year to 24,000,000 tons, and total stocks held in the country, distributed and undistributed, were now 2,000,000 tons higher than had been expected, the whole of this extra burden falling on the Board.

It was true, Sir James added, that in comparing the situation so far this year with the corresponding period of 1958, account must be taken of the fact that consumption in the early months of last year was fairly high. Moreover, if a quickening of industrial activity gave the stimulus to demand later this year which responsible forecasters expected, that, together with the measures to control global output, should keep the gap between supply and demand over this year as a whole lower than might otherwise be expected on present trends. Nevertheless, Sir James remarked, it was clear that the gap would almost certainly be a good deal more than originally anticipated and that the Board would stock more than 3,000,000 tons. The Board intended, however, to stick by its production plans for this year, both deep-mined and opencast. It was the Board's responsibility, Sir James said, to protect the interests of those who were employed in the industry, as well as to serve the country. The intention was to avoid further decisions on closures this year, bearing in mind the serious social consequences involved. Beyond that, the Board's plans for the future were now under consideration. So far as the vexed question of opencast was concerned production was already being limited to the absolute minimum without actually breaking contracts. By granting no new contracts, that in itself would ensure a level of output substantially below the level envisaged only a year ago. Even so, the rundown would be a difficult and costly operation and, since opencast provided some of the Board's most competitive tonnage, every cut must in the end make the burden of competition fall that much more heavily on the deep mines. That, Sir James emphasised, made the immediate task of securing a sustained improvement in productivity and costs so much the more important.

Export of Iron and Steel Scrap

At the request of the Ministry of Power, the Board of Trade has announced that arrangements have been made to permit the continued export of specified kinds of iron and steel scrap. An open general licence will be issued permitting during the period June 7 to September 6, inclusive, the export to any destination of scrap and old metal consisting wholly or mainly by weight of iron or steel and having an f.o.b. value not exceeding £25 per ton in the following forms : (*a*) compressed baled material, and (*b*) scrap turnings and borings. Inquiries about this licence should be made to the Board of Trade, Export Licensing Branch, Gavrelle House, Bunhill Row, London, E.C.1. The effect of this open general licence is, of course, to permit until September 6 next the free export of specified grades of iron and steel scrap, while safeguarding home supplies of better grades of iron and steel scrap.

Battery-Electric Vehicles

The annual report of the Electric Vehicle Association of Great Britain, which was presented at the annual general meeting on May 7, states that the approximate number of battery-electric vehicles in use in Great Britain and Northern Ireland at the end of 1958 was 35,917, compared with 34,852 in 1957. New registrations of battery-electrics during the year totalled 2293, of which the largest class was the 16 cwt–1 ton (unladen weight) numbering 589 ; there were 564 vehicles in the 1–1½-ton class, 409 in the 12–16 cwt class and 153 pedestrian controlled vehicles. Included in the total there were 338 vehicles exempt from road fund licence, and twenty-six invalid vehicles.

The Government's proposals for the testing of all vehicles ten years old or more, were the subject of negotiations between the Electric Vehicle Association, the Users' Association and the Ministry of Transport. Arising from these, a deputation led by the President of the E.V.A., Sir Wavell Wakefield, M.P., met Mr. G. R. Nugent, the Joint Parliamentary Secretary, Ministry of Transport, and put before him their objections to certain aspects of the proposals, and the necessity for electric battery vehicles to be treated in a different category from that of internal combustion engined vehicles. As a result of these representations, the report says, the Ministry agreed to exclude pedestrian-controlled vehicles from the regulations governing testing, but negotiations continue on the subject of the practical solution for testing driver-seated battery-electric vehicles.

Clean Air over Industrial Areas

The annual report for 1958 of the Chief Alkali Inspector makes reference to "increased responsibilities" since last June when the Alkali Act was extended to cover a further eleven classes of works. As a result, the number of registered works increased from 872 at the end of 1957 to 2160 at the end of 1958, and the number of separate processes at those works from 1733 to 3412. They include certain processes in iron and steel, copper and aluminium works ; power stations, gas and coke works, coal-fired producer gas plant, certain kinds of oil and coal-fired kilns for manufacturing pottery, bricks and tiles and coal-burning lime kilns. Some of the new works, the report says, are very large undertakings, particularly in the iron and steel industry, and the newer power stations.

The report deals at some length with the air pollution problems posed by the iron and steel industry, which are described as "perhaps the most difficult of all the new tasks facing the inspectorate." There are not only very large works with areas measured in square miles and responsible for appreciable pollution, but there are also furnaces at smaller works likely to cause complaint since many of these works are surrounded by houses. The report suggests that there is need for co-ordinated research and pilot scale and full-scale experiments before a solution to many of the problems can be found. Moreover, the Alkali Inspector thinks, for many of the problems, broad decisions at national level applying to the whole of the iron and steel industry may well be necessary.

Unemployment

The Ministry of Labour has announced that, on May 11, there were 481,000 people registered as unemployed in Great Britain. Of that total, 444,000 were described as wholly unemployed and 37,000 as temporarily stopped. Between April 13 and May 11, unemployment fell by 50,000, the wholly unemployed falling by 42,000 and the temporarily stopped by 8000. Expressed as a proportion of the estimated number of employees, unemployment on May 11 was 2·2 per cent, compared with 2·4 per cent in April and 2·1 per cent in May last year. The employment exchanges filled 148,000 vacancies in the four weeks ended May 6. The number of vacancies notified, but remaining unfilled on May 6, was 210,000, which was 12,000 more than a month earlier.

Ochsenkopf Television Tower

No. 1

A television transmitter tower of the Bayerischer Rundfunk, which came into service last December, comprises a 163m high reinforced concrete tower surmounted by a 13·5m high ultra-shortwave aerial mast and carrying on its outside the television aerial arrays. The tower, which has a total weight of 5000 tonnes, is designed to deflect up to 1·08m at wind velocities of 167km per hour. Besides fulfilling the stringent technical requirements, the design in concrete is stated to be convenient, in that equipment and staff are housed inside the tower itself, the feeder cables are kept short, and the aerial connections are accessible at all times. The aerials and warning lights are easily accessible ; maintenance costs are low, and the appearance of the tower is very satisfactory. The total cost of the station is claimed to be about the same as if a steel mast had been used.

THE Stockholm Conference of June, 1952, assigned to Bavaria eight television frequencies and transmitter sites, capable of serving some 75 per cent of the population. In addition to regional transmitters, local stations are used, which retransmit programmes so that they can reach localities in the shadow of mountains or other natural obstacles. After some modifications of the original conference decisions had been negotiated, the first regional transmitter on the Wendelstein, near the Austrian frontier, came into operation on November 1, 1954. Since then, a further five transmitters have been commissioned, of which the latest one is the one on the Ochsenkopf, in the Fichtelgebirge mountains in north-eastern Bavaria. The station, which replaces a local transmitter, came into service last December. Situated just below the summit, at 1013m above sea level, it is housed in a 163m high reinforced concrete tower which on the outside carries the television aerial arrays and is surmounted by a 13·5m high ultra-shortwave aerial mast.

Designed in four months and built in 260 working days spread over a period of just over one year, the tower is the third tallest structure in the Federal Republic, after the Stuttgart television tower (161m, 211m with aerial mast) and the Dortmund transmitter tower (173m without).

Much thought was given at the planning stage to finding the most economical way to fulfil the technical requirements. It was desired to send out a television programme in Band I at a strength of 100/20kW and two ultra-shortwave transmissions of 100kW each. Room was to be provided for the later installation of a polarised television transmitter of about 500kW for Band IV. The most suitable position for the centre of the television aerial array was found to be at a height of 109m above the ground. A 360 deg. emission with vertical polarisation was required. As the existing ultra-shortwave transmitters had been housed in temporary quarters in an existing observation tower, adequate accommodation for the new installation was not available and had to be constructed.

An aerial array for Band I with a gain of 12, comprising four storeys of four octagonal arrays, represents an assembly 40m high and weighing 20 tonnes. In an exposed position, like the present one, a wind load of 60 tons on this array had to be catered for, and the total design wind load on all aerials amounted to 80 tons. There was also the possibility to be kept open of adding a strongly polarised aerial for Band IV. The deflection of the tower under wind load and differential thermal expansion had, therefore, to be kept as small as possible.

In order to cheapen the design, various possibilities were considered but had to be rejected. Thus, single dipoles using the mast as reflector could have been employed instead of octagonal arrays. In that case, the required polar diagram would have imposed a limit of 1·2m on the diameter of the tower, a figure which could have been realised only with a guyed structure. This, in turn, would have required the felling of almost all the trees on the wooded top, which was not acceptable.

Accordingly, octagonal arrays had to be used. A substantial reduction in drag from 80 to about 34 tons could still have been achieved by heating the aerials and thereby preventing the formation of ice. In addition, however, it would have been necessary also to heat the reflectors (icing-up of the tower lattice work would have reduced the theoretical improvement somewhat). The cost of heating sixteen octagonal arrays, each measuring 4·5m by 9m, would, within ten years, have equalled the possible structural savings. Heating would also have necessitated installing a special diesel emergency set so as to safeguard the tower in all circumstances. Such a set would not otherwise be required for the transmitter.

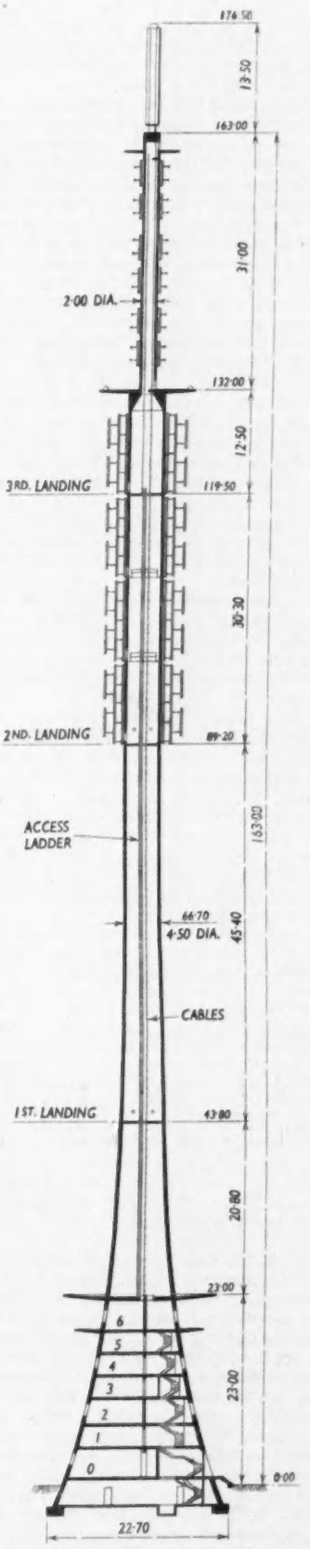
There remained the possibility of increasing the power of the transmitter and reducing the required gain of the aerials, leading to smaller and lighter aerials. A comparison of capital cost plus running costs over ten years for transmitters of 10kW and $2\times10=20$kW showed total figures of about DM.2,100,000 and DM.2,800,000 respectively, so that the lower-powered station appears to be the more economical solution.

In order to obtain an aerial output of 100kW, four storeys of octagonal arrays are required. Their combined height amounts to 50m to 60m, so that if the centre was to be 109m up, the height of the tower becomes about 130m. Above this level was to be placed the 27m high ultra-shortwave aerial. Although considerations of field strength would have permitted this aerial to have been placed below the television aerial, the tower diameter there, because of wind loads, reaches about 4·5m and this does not allow a sufficiently good polar diagram to be achieved with four dipoles at one level. A more complicated aerial would have been required, which would have used up the savings accruing from building the tower less high. These considerations led to the height of the reinforced concrete part of the tower to be fixed at 163m.

Calculation showed that a tower built in reinforced concrete was only slightly more expensive than a steel lattice tower, the one costing just over, the other just under, DM.1,500,000. Included in the figures are the provision of a separate station building with the steel tower, while the concrete tower itself houses the whole installation. Substantial savings are also obtained in the latter case where the transmitter is housed in the tower itself, owing to the fact that the aerial feeders are shorter. Moreover, the whole installation, including the aerial feeders, remains accessible in all weathers and the deflection is less. The decision, therefore, fell in favour of a concrete tower.

Founded on sound granite rock capable of supporting four times the actually imposed pressure (8 kg per square centimetre), the tower rests on a reinforced concrete ring of 22·7m outside diameter, 2m wide and let 1m into the rock excavated by blasting to a depth of 3·5m (see Fig. 1). From the foundation the tower ascends to the top at first in parabolic then cylindrical outline, interrupted at four levels by circular platforms which are designed to give easy access to the aerials, and protect them and the windows of the lower part of the tower from falling ice.

The outside diameter decreases from 19·1m at ground level to 4·5m at 66·7m in a parabolic sweep. Above this height the section remains constant. From 50cm at the bottom, the wall thickness decreases to 20cm at the top ; this dimension was made so large to facilitate placing the reinforcements, especially where the platforms are connected, and to increase the weight and thereby the stability.



Sectional elevation of tower. Datum 1013m above sea level ; all dimensions in metres

In the first 23m above ground level are housed on eight floor levels, totalling 1060 square metres, the whole of the station equipment and ancillary offices. The basement contains the electric substation, a heavy workshop and ventilating plant for the television transmitter. At ground level is the new television transmitter, while the first upper floor houses the ventilators for the two 10kW ultra-shortwave transmitters on the second floor. Floors 3, 4 and 5 house living quarters, a kitchen and sleeping quarters for the staff, while the sixth floor is occupied by post office equipment. The whole amounts to

4500 cubic metres of space. A covered corridor 40m long gives protected access to the tower and is designed to withstand blocks of ice of 150 kg falling from a height of 100m.

For the structure, concrete to standard B300 was chosen, with a minimum cube strength of 300kg per square centimetre after twenty-eight days, which could easily be achieved with local aggregates and 320kg cement per cubic metre. Longitudinal reinforcement consisted of deformed bars of No. IIIa steel, with a tensile strength of over 5000 kg per square centimetre, while the transverse reinforcements were of normal No. II structural steel.

Concreting of the tower began on November 4, 1957, and before the end of the year three storeys had been completed. This good progress was made possible by using prefabricated wooden shutter plates which were made at a local sawmill. The concrete was poured one storey at a time. During the winter months much difficulty was caused by hoar frost and the cold winds to which the site is exposed. Work was interrupted until mid-March ; in the succeeding month, the remaining five storeys were completed in spite of up to 14 deg. Cent. of frost, and by the end of May, 1958, the whole station structure up to and including the large 23m platform had been completed.

For the next section, from 23m to 67m, with double-curvature surface, a vibrated concrete was used. A suitable system of shuttering was not available, and so had to be specially developed. A climbing shuttering was used and this portion was completed in successive 2m high steps within five weeks. Because of this favourable result, the same system was used for the remaining 65m which were cylindrical in section, and which were completed by August 15, in just over six weeks, at the rate of 2m per working day. This, it is stated, compared favourably with a sliding shuttering and was cheaper. The 29m high tower above the platform at the 132m level was constructed at the rate of 4m per day, using a standard system of hydraulic sliding shuttering. At all stages, any required fasteners for aerials, cables and warning lights were incorporated.

The principal data of the tower are summarised in the accompanying table :

Ochsenkopf Television Tower

Height of tower datum above sea level		1013m
Overall height of tower above datum		176·5m
Depth of foundations below datum		3·5m
Height of reinforced concrete part		163m
Height of 1st platform 19m	diameter	16m
Height of 2nd platform 23m	diameter	19m
Height of 3rd platform 132m	diameter	12m
Height of 4th platform 161m	diameter	7m
Wall thickness at level of 2nd platform		40cm
Wall thickness at 163m level		20cm
Reinforcement steel		370 tonnes
Cement		750 tonnes
Ballast		4000 tonnes
Timber		200m³
Maximum design wind force		192 tonnes
Total weight of tower		5000 tonnes

The concrete structure was completed by the middle of September, but already well before then, in June, work was started inside the station quarters. This was made possible by mounting a tower crane on the 23m platform, by means of which the materials for the higher portion could be hoisted up, by-passing the station. From this platform to the 132m level, the materials were transported by an interior hoist. Above that height, the internal diameter amounted to only 1·6m, and was entirely taken up by the sliding shuttering. An external tubular scaffolding for the workmen and for a materials hoist was therefore erected on the 132m platform and extended to the top. Difficulties with the weather continued during the summer. On several days, wind velocities of over 100km per hour caused the work to be suspended. Lightning repeatedly hit the tower, but caused no injury or damage owing to the steel shuttering being earthed at all times to the reinforcement, so that the workmen could safely shelter inside. No serious accident occurred during the whole of the work.

(To be concluded)

Picote Power Station

On April 19, the official opening took place of Picote Power Station on the river Douro. The station is on the 112km-long international section where the river forms the frontier between Portugal and Spain. Of the remainder, 525km are in Spanish, and 213km in Portuguese territory. The common exploitation of the present section, which receives water from a catchment area of 97,000 square kilometres, was agreed upon by the two countries in 1927. For Portugal, a complete harnessing of the Douro will increase the annual amount of electricity production by 5GWh of which 2GWh come from the international section. Along the Portuguese contributaries an annual reserve of 4GWh is being created.

The Portuguese programme for exploiting the international section of the Douro comprises the construction of three power stations, of which Picote is the most important. This station has a 95m-high arch dam with a concrete volume of 220,000 cubic metres, equipped with four crest gates each 20m wide and 8·9m high and capable of overspilling a totalling of 10,400 cumecs. The penstocks have an internal diameter of 5·5m and the galerie d'evacuation a discharge capacity of 600 cumecs.

The turbine hall is underground and measures 88m in length and 16·6m in width. It is equipped with three vertical Francis turbines, each of 93,000 h.p., operating at 166 r.p.m., under a head of 70·4m. The flow through the turbines is 330 cumecs. Turbines, regulators and their ancillary equipment were built at the Grenoble works of Ets. Neyrpic. The alternators have an individual capacity of 60MW. Current is generated at 15kV and stepped up to 220kV in transformers with a total capacity of 225MVA. The station is to produce 1GWh per annum.

Surface Texture Reproduction

A plastic compound, for making casts of surfaces, that is produced by Hommel Werke of Mannheim, is now available from Rubert and Co., Ltd., Acru Works, Demmings Road, Cheadle, Cheshire. The compound is supplied in a kit including a cleaning fluid, a powder and a liquid, and some "plasticene." The surface is first cleaned and a small area is then defined with a dam of "plasticene." The powder and the liquid are then mixed to form a cream which pours easily on to the surface. The cast is then left about ten minutes to set and, we are advised, penetrates the smallest cavities. The compound does not shrink on solidification, and thus reproduces an image of the surface without distortion.

We have examined an end-milled Rubert standard surface of roughness 190μin C.L.A. (average departure from centre line) and a plastic negative of this standard. Talysurf traces of these two surfaces are reproduced here : the surfaces are described in each case as 180–200μin C.L.A. It is pointed out that only C.L.A. and maximum amplitude (in this case 1300μin) are the same for original and replica. It can be seen that there is a superimposed waviness on the peaks of the original which appears in the troughs of the replica, and this causes the replica to feel smoother to the thumbnail. The plastic replica is hard, resisting scratching with a penknife, and suitable for handling in the workshop. Apart from the advantages of having a permanent record of the surface of a workpiece and of not needing to take a rather expensive surface roughness measuring instrument to each job in turn, it is pointed out that the process is applicable to inaccessible surfaces such as may be found in small holes.

Dortmund–Ems Canal

An improvement in utilisation of 30 per cent of the available tonnage has been made possible by the opening, on April 2, of the Dortmund–Ems Canal to ships of 1000 tons laden to a draught of 2·5m. The deepening of the canal was completed after eight years of work, at a cost of nearly DM.194 million, of which DM.65,000,000 were spent on the 108km-long southern portion between Dortmund and the Mittelland Canal at Bergeshövde. The work there involved the rebuilding of twenty bridges and twelve conduits and service crossings, as well as the alteration of the locks at Münster. Work on twelve further bridges and crossings will be completed this year. The northern stretch of the canal was rebuilt at a cost of DM.128 million, of which a large proportion was spent on making the locks suitable for ships of 1350 tons, as the canal can be made suitable comparatively easily for fully-laden ships of this tonnage. The improvements had been contemplated for many years. Work on the 200km-long Dortmund–Papenburg stretch was discontinued during the war.

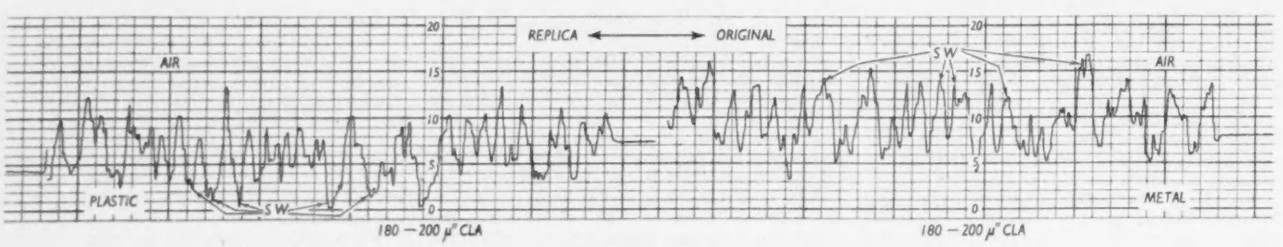
French Railway Electrification

French Railways have announced the introduction of electric traction with 25kV, 50 c/s alternating current on two more sections of line in North-Eastern France : Conflans–Pagny-sur-Moselle (21 miles), and Metz–Lerouville–Bar-le-Duc–Revigny (72 miles). These sections both complete links between the already electrified Lille–Bâle line and the Paris–Strasbourg line now in course of electrification, while the second section also covers part of the latter line between Lerouville, Bar-le-Duc and Revigny.

The total length of electrified lines on the French Railways is now 4251 miles; 25kV, 50 c/s a.c. is used on 1056 miles. Almost all of the remainder is operated with 1500V d.c.

Machinery and Equipment Fair, Utrecht

From October 12 to 20 inclusive a fair for machinery and equipment for the chemical and pharmaceutical industries, for the food-processing industry and for the dairy industry, will be held at Utrecht. This is the fourth occasion on which the fair is being held ; its name has been changed from " Vochema " to " Machevo." At the last exhibition, which was held in the autumn of 1956, approximately 500 Dutch and foreign firms were represented, occupying a net stand space of 93,500 square feet. Apart from Dutch firms, those taking part included manufacturers from Great Britain, the U.S.A., Germany, Switzerland, Sweden, Denmark, Italy, France and Belgium.



SW = Superimposed wave.

Surface texture reproduction : records of surface profiles of plastic cast (left) and original (right)

American Nuclear Engineering Conference

BY OUR AMERICAN EDITOR

No. III—(*Continued from page* 827, *May* 22)

The fifth Nuclear Engineering and Science Conference was held at the Public Auditorium in Cleveland, Ohio, from April 5 *to* 10, *in conjunction with the* 1959 *" Atomfair " exhibition. The conference was organised under the sponsorship of the Engineers Joint Council in co-operation with twenty-seven American and Canadian engineering institutions. The exhibition was sponsored by the Atomic Industrial Forum and presented a comprehensive picture of the current state of development in the application of atomic energy in American industry.*

General Electric Company

ONE of the highlights of the Atomfair was the display of the General Electric Company, of Schenectady, New York, which emphasised the firm's remarkable " Technical Development Programme " designed to help industry meet the demands of atomic acceleration in the shortest possible time, at the least cost, and with manageable technological and financial risks. Called " Operation Sunrise," it is a carefully planned, clearly defined programme to accelerate a concentrated development of the boiling water reactor, aimed at achieving competitive nuclear power in a significant portion of the domestic market by 1969–71. The programme is based on the convictions of solid experience. The course to be followed is well defined—based on design studies of promising reactor systems, analysis of the experience gained from reactor programmes to date, analysis of the development still required to advance various reactor systems, and evaluation of the performance and economics of each system. It is a practical straightforward course, and can be carried out within a predictable time, at predictable costs and with minimum risk.

Attaining competitive nuclear power at least cost and as quickly as possible requires the concentrated development of the reactor system that now is well established, has the most promising cost potential, and has a clearly predictable path of development. In the firm's opinion, the boiling water reactor (BWR) meets these conditions. The technological foundation for boiling water reactors is firmly established through experimental data, design and construction experience, and operating experience from six " first-generation " reactors, and a number now in the design and construction stages. Various experiments have proved the stability and safety of the BWR. Significant in supplying design and construction experience are the Experimental Boiling Water Reactors at the Argonne National Laboratory and the Vallecitos Atomic Laboratory, and the Commonwealth Edison Dresden Nuclear Power Station now completely designed and due for start-up in 1960. The boiling water reactor was selected for the SENN project in Italy.

It is claimed that the lowest capital costs of any proven reactor are those of the boiling water reactor. These result primarily from the extreme simplicity of the BWR system. Construction costs have been accurately predicted—the Dresden plant construction is proceeding within its original budget and the Vallecitos Boiling Water Reactor was completed under budget.

General Electric has carried out extensive analyses to determine a clear course to economic atomic-electric power plants. This effort involved design studies of promising reactor systems, analyses of other reactor programmes to date, analyses of development still required for advancing various designs, and an evaluation of the performance and economics of each system. The company will continue to investigate other promising reactors while implementing a major effort in developing boiling water reactors in depth. Present analyses indicate the following basic reasons why the boiling water reactor is ready for intensive development in depth : (1) In the U.S.A., more extensive development has been done with boiling water power reactors than with any other reactor. As of January, six boiling water reactors have been constructed and operated, three are presently under construction, and three others have been committed. (2) The BWR system is simple, and consists largely of components proven by conventional steam power station practice. The reactor core construction is simple. (3) Cycle efficiency is comparatively high because steam is fed into the turbine at reactor pressure. Auxiliary pumping power is low. (4) Nuclear superheat is a logical extension of the direct cycle BWR, and holds great promise for making conventional steam conditions possible. (5) The safety characteristics of the boiling water reactor have been proved in the A.E.C. Borax and SPERT experiments, the only series of comprehensive safety experiments that has been performed for any American reactor to date. (6) Capacity for increasing power density has been shown by the EBWR and the VBWR, and no unsolvable technological barriers appear to stand in the way of even further increases. (7) The low-enrichment, uranium-oxide fuels have demonstrated their feasibility for commercial service. Practical manufacturing processes have been developed ; oxide fuel is corrosion-resistant and stable under irradiation. (8) Operating experience has shown a number of salient advantages of the system for utility power operations.

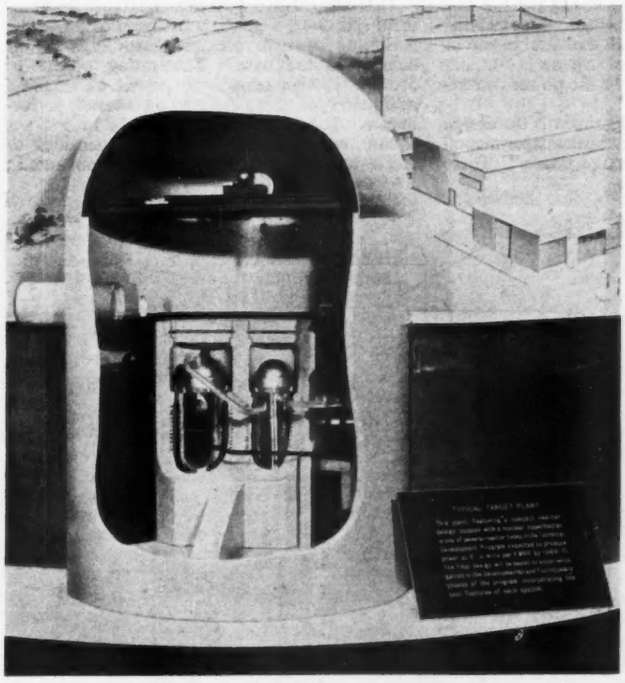


Fig. 13—Model of General Electric " target plant " atomic power station with nuclear reactor and nuclear superheater

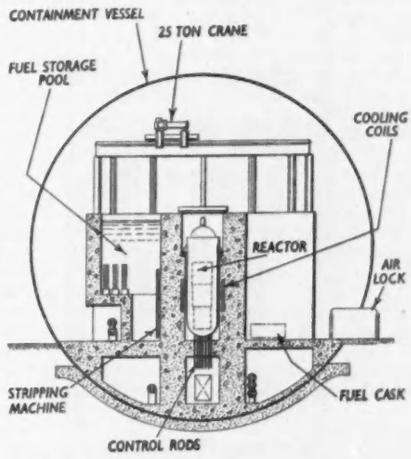


Fig. 14—50eMW natural-circulation boiler reactor development being designed for the Pacific Gas and Electric Company

Ease of operation : the VBWR is run by one foreman and two operators per shift. Reliability of operation : the availability of the VBWR has been extremely high ; the Pacific Gas and Electric Company calculated an availability of 98·6 per cent for June, 1958, 91·5 per cent for July, 1958, and 96·3 per cent for August, 1958. Low radioactivity levels : the level in the VBWR turbine exhaust casing is about 17 mr per hour during power operation. The average operator exposure for one year of operation has been 200 mr. Turbine maintenance has been accomplished in a normal way with no radiation problems: dismantling of the turbine for inspection was accomplished on a seventy hour per week schedule per worker, and workers received only one-fourth of the weekly permissible dose. Stable operation : the operation of the VBWR and EBWR at various pressures and power levels has demonstrated that operation is stable even at high power densities. Rapid response to load change : load changes from 200kW to 5000kW in fifteen seconds are regularly performed in the VBWR with a change of only 30 lb per square inch in reactor pressure. Ease of start-up : start-up time of the VBWR from cold conditions to full power is about five hours. To shut down the reactor, open the vessel, rearrange or replace fuel bundles and restart the system requires only twenty-four hours.

With this technological base, General Electric is now ready to work on the following specific technological objectives that will lead to economical operation : (1) Increased power density —to double the power output from 30kW per litre of reactor core volume to 60kW per litre. (2) Simplified and compact plant design —to simplify the steam supply system, make plant layout more compact, reduce containment costs and increase plant reliability. (3) Improvement in steam conditions—to increase thermal efficiency from the present 28 per cent to over 32 per cent with saturated steam, or 35 per cent to 37 per cent with superheating. (4) Increased

plant size—to raise the present practical size from 200MW for a saturated steam plant to over 450MW for a superheated steam plant. (5) Improved fuel performance—to double specific power from 10kW to 20kW per kilogramme ; develop reliable fuel performance for exposure up to 15,000 megawatt-days per ton ; reduce

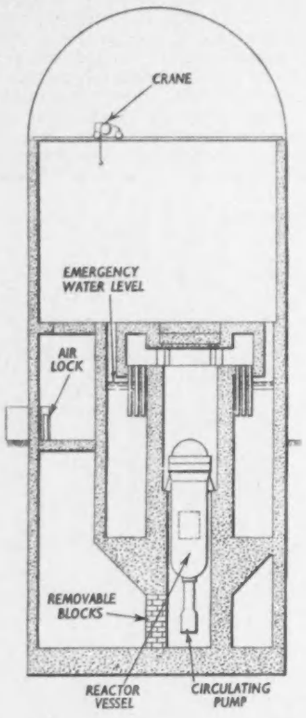


Fig. 15—25eMW compact reactor development of the General Electric Company

fuel fabrication costs by approximately 50 per cent ; increase allowable operating temperatures up to 1000 deg. Fah. steam outlet temperatures ; and improve neutron economy.

It is felt that achieving these objectives will produce economic nuclear power plants. Achieving all objectives completely may not be practical; for example, higher specific power may be attained only at the expense of higher fuel-fabrication costs. Therefore, concurrent advancement toward all objectives is necessary to obtain the optimum blend of technologies.

The goal of the Technical Development Programme is to reduce nuclear plant capital costs to 175–225 dollars per kilowatt and fuel costs to 1·8–2·2 mills per kilowatt-hour (1 mill—0·001 dollar). The programme is devised to make the best use of the wealth of present technical information on boiling water reactors and to gain the additional information needed to advance nuclear power from its present state to the point where it is competitive with conventional power. It travels a clearly defined route—along the familiar lines of normal industrial development. Basically, the programme is built on the simple concept that each successive reactor design will incorporate the best features of the preceding designs, with innovations resulting from research and development work directed toward specific areas of technology. An extremely simplified diagram of the process would show a " narrowing down," or decrease, in the number of reactors in each successive generation, the final result being a plant having the best combination of the best features of the preceding developments. The actual final result, in all likelihood, will be a number of " target plants," possibly two or three, of different design to cover a complete range of plant ratings up to approximately 450MW. Fig. 13 shows a model of one of these final power plants as exhibited at the Atomfair.

The programme follows three major avenues of development : (1) Natural-circulation reactors. (2) Forced-circulation reactors : (*a*) compact ; (*b*) high power density. (3) Superheating reactors. The starting point for the first two, the natural and the forced-circulation reactors, is the development represented by the Argonne National Laboratory's Borax, SPERT and EBWR programme, and the General Electric Company's Vallecitos Boiling Water Reactor and Dresden Nuclear Power Station designs. These " first generation " plants provide the basis for more advanced designs and allow the mapping of the programme outlines to the achievement of competitive nuclear power.

The first avenue of development, natural-circulation reactors, is a direct extension of the Vallecitos Boiling Water Reactor into plants of higher ratings. It presently appears that simple reactors of this type might be built in ratings up to approximately 150MW.

The second avenue of development, forced-circulation reactors, is divided into two lines. One, the " compact " reactor, attacks the cost reduction problem for large plants by developing a compact plant layout, enabling direct cost savings in plant construction. The high power density line of forced-circulation reactors is directed to the technical objective of substantially increasing the power output of a given reactor core and increasing maximum unit rating, thus reducing the unit capital costs of a reactor plant of a given physical size.

The third avenue of approach, superheating reactors, is directed toward the attainment of high thermal efficiencies, as well as the attainment of lower capital costs of the power conversion equipment.

The key to the entire programme is the design and construction of the four initial experimental projects in the " Developmental Phase." These are the Natural Circulation Boiler–2, which is a 50MW plant presently being designed for the Pacific Gas and Electric Company ; the Compact–1, a small forced-circulation reactor of 10–25eMW ; the High Power Density–1, with a minimum-sized core for a rating in the range of 25 to 50eMW ; and either a separate superheater to be added to an existing boiling water plant or an internal superheater. The progress in design and development of these reactor experiments will indicate whether any of the reactors in the second group of developmental reactors is required.

The Natural-Circulation Boiler Reactor Development (NCB–2),

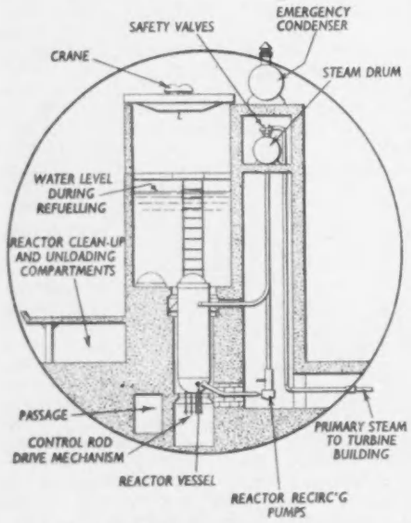


Fig. 16—High power density reactor development of the General Electric Company

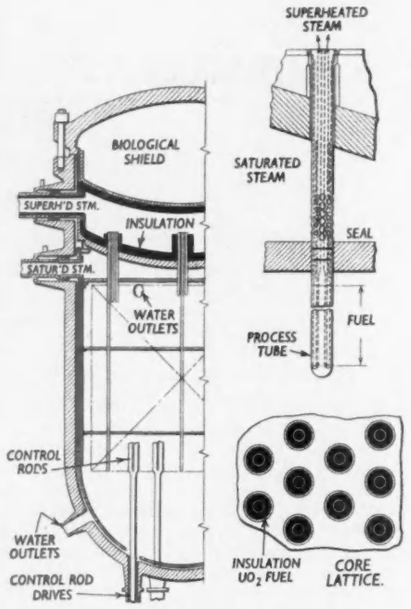


Fig. 17—Separate superheater reactor development of the General Electric Company

Fig. 14, utilises an advanced natural-circulation reactor with internal-gravity steam separation and a low-pressure drop core. This reactor is being designed by General Electric for the Humboldt Bay Station of the Pacific Gas and Electric Company. A feature being considered for this plant is a water-pool pressure-suppression system which will materially reduce the cost of containment. This advanced development is expected to provide basic data leading to a larger (50–300MW) power plant competitive in high-fuel-cost areas in the United States.

The compact reactor development (C–1), Fig. 15, is designed to prove the feasibility of forced circulation utilising an integrally mounted pump. Designed to minimise pumping power requirements, the reactor also permits the use of a small biological shield. Mechanical steam separators will be used inside the pressure vessel, and a side-entry control system will permit the mounting of the pump in the bottom head.

The High Power Density Reactor Development (HPD–1), Fig. 16, is designed to prove the feasibility of high pressures with high power density in the core. The rating of 25 to 50eMW is high enough to permit an accurate evaluation of these factors on overall performance. The system pressure will be 1465 lb per square inch absolute and power densities of 50kW to 65kW per litre will be demonstrated ;

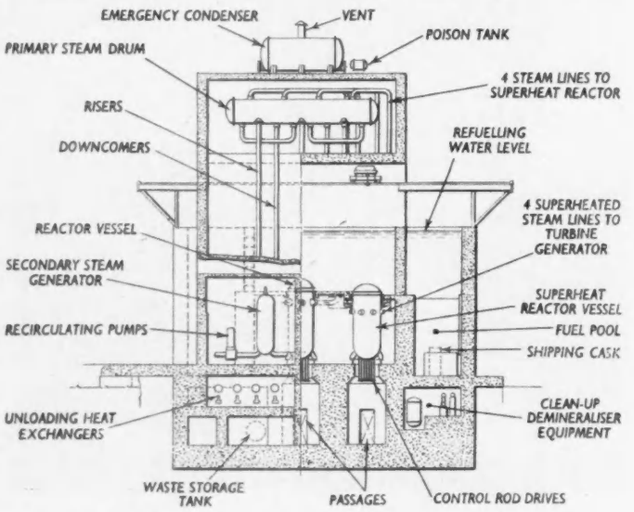


Fig. 18—460eMW high-power-density superheater atomic power station proposed by the General Electric Company

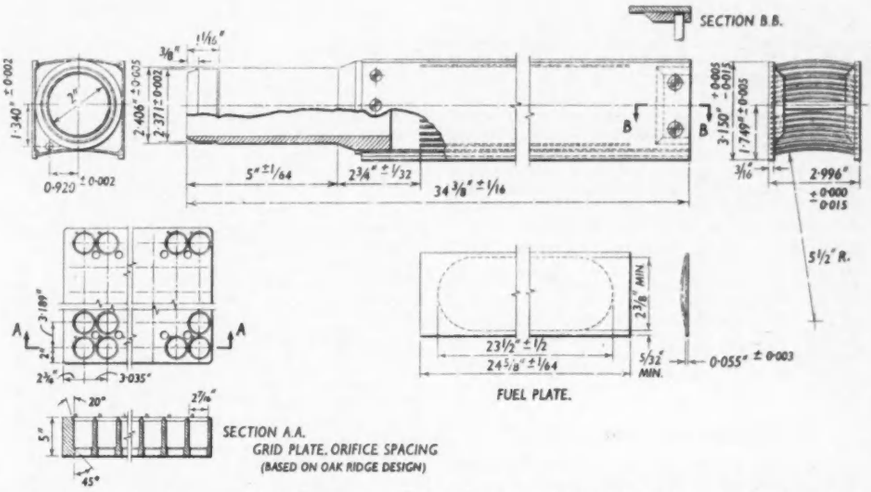


Fig. 19—Sylvania-Corning standard MTR-type fuel element with curved fuel plates for pool research reactors

other characteristics of the reactor are based on systems already demonstrated in the VBWR. The performance of this development programme will determine whether a second developmental reactor will be required before reaching power costs competitive in high-fuel-cost areas in the United States.

The Separate Superheater Reactor Development (SSH–1), Fig. 17, involves a nuclear superheater to be coupled to an existing power plant reactor. The recommended rating of the superheater is 50eMW, although the development could probably be accomplished in ratings from 10 to 100eMW. The plant will have conservative temperatures and pressures (825 deg. Fah. and 915 lb per square inch), so that the operation and maintenance of the separate superheater can be carefully evaluated. The use of two reactors will permit greater flexibility and permit testing of superheater fuel and control over a wide range of conditions. The superheater development will permit a future extension to the largest permissible unit sizes and reduce the capital cost of turbines and auxiliaries.

The " Evolutionary " series of nuclear power stations will be full-scale plants in ratings from 50MW to 300MW, and will utilise the technological development resulting from the " Developmental Reactor " series. They will be competitive in high-fuel-cost areas of the United States, producing power at about 8½ mills per kilowatt-hour. The so-called Natural-Circulation Boiler Plant (NCB–4) of 100eMW capacity will incorporate mechanical steam separation within the pressure vessel, using the proven features of the EBWR, VBWR and NCB–2. The large core will permit demonstration of methods for maintaining stable power distribution in spite of low neutron leakage. An advanced type of control system will be incorporated to reduce tolerance problems associated with the core. Pool containment will be used to minimise capital costs.

A 200eMW compact plant (C-3) will demonstrate many of the features of the preceding plants on a larger scale and will further increase core power density. It will require more efficient steam separating equipment and a larger recirculating pump. Like the smaller plant of this series, it will also incorporate pool containment, an internal pump and a side-entry control system.

Finally, a large, 200eMW, high power density plant (HPD-3) is a logical extension of previous smaller plants in this series. By combining the high-pressure experience gained from these plants with the extensive plant experience of the Dresden station, this power station should demonstrate a very low fuel cost. A low-pressure containment structure and mechanical steam separation will be used to minimise the capital cost.

The reduced costs of the final " Target plants," which will operate at about 6½ mills per kilowatt-hour, result essentially from larger unit rating. Continuing development will lead to nuclear plants that will be considered " conventional." Fig. 18 shows a 460eMW high-power density-superheater plant, which will make possible the achievement of both a minimum capital cost and a minimum fuel cost. The plant will consist of a combination of a separate superheater with the HPD-4 boiling reactor. Forced circulation provided by close-coupled pump loops will be used together with a low-pressure containment structure. A 300eMW natural-circulation boiler plant will employ two identical natural-circulation boiling reactors. Each of these reactors represents an extension of the NCB-4 design. This plant represents a minimum in technical innovation, the major cost reductions occurring through manufacturing and construction experience, and the savings possible with a large installation.

A 300eMW compact-superheater plant will consist of a C-3 reactor combined with a separate nuclear superheater. Forced circulation in the reactor will be provided by an internal pump and the plant will utilise pool containment to obtain lower construction costs. Finally, a 300eMW high power density plant will be based on a power density of 75kW per litre. It is similar to the HPD-3 design in all respects except size and will feature close-coupled pump loops and low-pressure containment.

Sylvania-Corning Nuclear Corporation

This firm was formed at Bayside, New York, in 1957, to merge the nuclear activities of Sylvania Electric Products, Incorporated, and the Corning Glass Works. To-day, the new company is probably the largest single group in the United States employed exclusively in such work. Its resources are actively engaged in the production and development of fuel elements and fuel element materials, fuel assemblies, reactor components, such as control rods, moderators and reflectors, and a variety of reactor accessories, including pumps, control rod drives and test loops. The firm fabricates nuclear fuel elements in a wide variety of shapes and configurations, including solid and hollow slugs, rods, tubes, flat, curved and corrugated plates, wire, wafers with and without perforation, wafer assemblies, pellets and spheres, and foil. The economic production and reprocessing of nuclear fuel is now one of the most critical factors in the ultimate attainment of competitive electric power from the atom. The company has processes under advanced development for effecting the economical recovery and refabrication of irradiated fuel elements. These processes are intended to be an integral part of the complete fuel cycle, which includes fuel element manufacture and reprocessing. Sylvania-Corning is also actively studying methods for the metallurgical refabrication of fuel elements into a new reactor charge in lieu of chemical reprocessing, as a means of reducing the equivalent nuclear fuel cost. Through the use of this knowledge in fuel reprocessing, coupled with its broad background in fuel element fabrication, the firm plans to provide a complete out-of-pile service to reactor designers, builders and operators.

An interesting development in the nuclear field recently introduced by Sylvania-Corning is the production of " standard " fuel elements. These units are being made initially in four designs, which were exhibited at the Atomfair. Two designs use curved plates and two use flat plates, all being fuelled with 90 per cent enriched uranium. Two elements are of 18-plate design and two of 10-plate design. The 18-plate elements are loaded with 196 grammes of uranium-235 ; the 10-plate elements with 165 grammes o uranium-235. The introduction of standard fuel elements is considered to be a major step forward in the firm's programme to effect substantial reductions in over-all fuel element design and manufacturing costs. Standard elements eliminate the cost of custom design, special engineering, estimating time, special tooling and testing, and permit the maker to stock and deliver fuel elements " off-the-shelf." Compatible standard control elements and standard grid plate orifice designs will also now be available.

The first four standard fuel element types have been established to cover a high proportion of the necessary designs for nuclear research reactors being planned to-day. Some of the standard fuels can be employed in existing reactors both in the United States and abroad.

Fig. 19 shows the design of a representative standard fuel element as employed in " MTR " type pool research reactors. The individual fuel plates are made by encasing a fuel filler of uranium and aluminium alloy fuel material within an aluminium cladding in a manner which ensures complete bonding and cladding integrity. The fuel plates are constructed and mechanically assembled into fuel and control elements. The virgin aluminium for the filler alloy is 99·9 per cent pure aluminium, ASTM-B24-46 Grade 9930A. The aluminium for the cladding is Type 1100, ASTM-B209-SST Grade 990A. The aluminium for the end fittings is cast Type 356-T7. The uranium used in the fuel elements is enriched to 90 per cent U-235.

One randomly selected plate from each melt is radiographed to obtain a permanent record of homegeneity and fuel location. This radiograph becomes the property of the customer. The bonding between cladding and fuel of individual plates is inspected by means of a " blister " test consisting of heating the completed plates to 950 deg. Fah. for two hours at temperature. No plate exhibiting raised or blistered surfaces within ¼in of the core area is included in a fuel element assembly. The surface contamination of plates assembled into fuel elements is not greater than the equivalent of 10 microgrammes uranium per square foot of surface area.

The company was recently chosen to produce an initial loading of 100 core sub-assemblies and 300 blanket sub-assemblies, made to one of the most intricate fuel element designs yet developed for the Enrico Fermi Fast Breeder Atomic Power Station. The core sub-assemblies (Fig. 20) will consist of a centre section containing 144 co-extruded zirconium-clad pins of 0·158in diameter, composed of 25·6 per cent enriched uranium-molybdenum alloy. The end sections will consist of sixteen rods, 0·443in in diameter, composed of stainless steel cladding, sodium-bonded to depleted uranium-molybdenum alloy. The blanket sub-assemblies are made up of twenty-five full-length rods similar to those in the end sections of the core sub-assembly.

Fig. 20—Core sub-assembly for the Enrico Fermi atomic power station with co-extruded zirconium-clad fuel pins of uranium-molybdenum alloy

(*To be continued*)

Personal and Business

Appointments

MR. NORMAN STAFF has been appointed managing director of Winget, Ltd.

MR. S. H. LAWRENCE, general manager of Raydex, Ltd., has been appointed a director.

MR. NORMAN D. MATHIE has been appointed assistant secretary of Johnson and Phillips, Ltd.

MR. D. N. GIFFORD, commercial manager, has been appointed a director of Birlec-Efco (Melting), Ltd.

MR. CHARLES A. BURTON joins A.R.O. Machinery on June 1, to take over new projects and developments.

THE EARL OF HALSBURY has been appointed to the board of Lancashire Dynamo Electronic Products, Ltd., as chairman.

MR. ROBERT L. COGDALE has been appointed European resident technical representative of Marconi Instruments, Ltd.

MR. EDWARD DAVIS has been appointed marine superintendent of the Marconi International Marine Communication Company, Ltd.

WILLIAM DOXFORD AND SONS (ENGINEERS), Ltd., announces that Dr. Finn Orbeck has been appointed as senior technical engineer to the company.

SIR JOSIAH ECCLES, M.Inst.C.E., M.I.Mech.E., M.I.E.E., has been appointed president of the Electrical Development Association for the year 1959/60.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., announces that Mr. L. S. Tredgett has been appointed assistant sales manager, railway signals department.

THE LONDON CHAMBER OF COMMERCE announces that Mr. Allen L. Stock has been re-elected chairman, Mr. Richard L. Wills, deputy-chairman, and Mr. F. H. Tate, treasurer.

MR. J. O. M. FISHER, a director of Humber Graving Dock and Engineering Company, Ltd., has been elected chairman of the Dry Dock Owners and Repairers Central Council for 1959/60.

THE ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY states that Dr. Samuel C. Curran, F.R.S., has been appointed principal in succession to Sir David Anderson, who is to retire later this year.

THE SPIRAL TUBE AND COMPONENTS COMPANY, Ltd., states that Mr. A. Wilkinson is to retire from the position of managing director on July 1, to become deputy chairman of the company. He will be succeeded by Mr. K. J. Wilkinson.

GENERAL ELECTRIC COMPANY, Ltd., has announced that Mr. M. R. Neville, manager of the publicity organisation, is retiring on June 30, after forty years' service with the company. Mr. A. C. V. Clarkson will take over as manager on July 1.

BRUCE PEEBLES AND CO., Ltd., announces that Mr. F. Duerden, A.M.I.E.E., has been appointed manager of the electronics department in succession to Mr. J. W. Haig Ferguson, A.M.I.Mech.E., who has been promoted divisional director.

MR. N. E. CHANNING has been appointed technical publicity manager for W. E. Sykes, Ltd., and Sykes Machine Tool Company, Ltd. The publicity department has moved to Hythe End House, The Hythe, Staines, Middlesex (telephone, Staines 5076).

THE ENGLISH ELECTRIC COMPANY, Ltd., announces that Mr. G. E. Robertson, A.M.I.E.E., has been appointed manager, sales and contracts, of the meter, relay and instrument division, and Mr. P. G. Bevis has been appointed manager, sales and contracts, relay department.

PROFESSOR ARKADY N. RYLOV, of the Soviet Union, has been appointed to the post of deputy director general in charge of the department of training and technical information of the International Atomic Energy Agency. He succeeds Professor V. V. Migulin, also of the Soviet Union.

PRIOR STOKERS, Ltd., announces that Colonel A. de Chimay, A.M.I.C.E., managing director, has also been elected chairman, following the death of Mr. F. P. D. Scott. Major General Sir Miles Graham has been elected vice-chairman, and Mr. J. P. Anderson has taken over the duties of sales director.

E.V. INDUSTRIALS, Ltd., announces that Mr. J. I. Taubman and Mr. Adrian Jacobs have been elected additional directors, and Mr. Taubman has also been elected chairman. Mr. Philip N. Hoyle, a director of the company, has been elected vice-chairman. Mr. Edward Langton has resigned from the board of the company.

MR. J. R. WILKINSON, managing director of Ferguson Pailin, Ltd., director of Switchgear Testing Company, Ltd., and member of the BEAMA Council, has been appointed deputy chairman of the Association of Short-Circuit Testing Authorities (Inc.) Council. Mr. S. E. Goodall has been appointed to the Council in succession to the late Sir John Dalton.

THE BRITISH OIL BURNER MANUFACTURERS ASSOCIATION, Ltd., states that Mr. J. D. FitzGerald has been elected president and that the other elections were : vice-presidents, Messrs. W. C. J. Mollison and A. M. Wood ; technical adviser, Mr. R. H. G. Sutton ; Council, Messrs. H. F. C. Newsom, P. A. Martin, J. R. Ball, E. G. Brooks, R. L. Cox, K. R. Green, W. G. Myatt, R. W. Towers, and A. K. Waugh.

Business Announcements

CONCRETE (SOUTHERN), Ltd., has opened a new works at Chadwell St. Mary, near Tilbury.

SIEMENS EDISON SWAN, Ltd., states that on June 1, its London district office will move to Crown House, Aldwych, W.C.2 (telephone, Temple Bar 8040).

BRITISH INSULATED CALLENDER'S CABLES, Ltd., announces that the telephone number of its Middlesbrough branch is now Middlesbrough 3974/5.

R. W. GREGORY AND PARTNERS, Consulting Engineers, 1, Brazennose Street, Manchester, 2, state that Mr. Hugh G. Bell, M.I.E.E., has joined them as consultant.

W. H. ALLEN, SONS AND CO., Ltd., Bedford, announces the transfer of its branch office in Scotland to new premises at 234, St. Vincent Street, Glasgow, C.2 (telephone, Central 5906/7). Mr. Henry Winter is the manager of the new office.

GILBERT GILKES AND GORDON, Ltd., Kendal, Westmorland, states that it has revised its pump sales organisation for Glasgow and the south of Scotland and has appointed Winter, Montgomery, Ltd., 234, St. Vincent Street, Glasgow, C.2, as its agent.

RESEARCH AND CONTROL INSTRUMENTS, Ltd., Instrument House, 207, King's Cross Road, London, W.C.1, is distributing a new range of Philips automatic conductivity measuring equipment, permitting continuous measuring recording and control of the strengths of process solutions.

J. H. FENNER AND CO., Ltd., has announced the formation in Sydney, Australia, of a manufacturing company for mechanical power transmission goods by means of an association between the Dodge Manufacturing Corporation of Mishawaka, Indiana, and the Fenner Company in Hull.

I.B.M. UNITED KINGDOM, Ltd., 101, Wigmore Street, London, W.1, states that it has opened a European educational centre at Blaricum, near Amsterdam, Holland. Seminars for executives from West European countries will be run each week, dealing with specialised subjects or specific industries and applications.

THE GENERAL ELECTRIC COMPANY, Ltd., has established a new sales and distribution area office at Magnet House, Hangar Lane, Ealing, W.5 (telephone, Perivale 6691), which will cover the North London, Eastern and Southern Counties area, including the existing branches at Ipswich, Dagenham, Luton, Reading, Southampton and Bournemouth.

F. PERKINS, Ltd., Peterborough, has announced that it has acquired Sugg-Solar, Ltd., of Westminster, which, as related on page 633, May 6, 1955, holds a licence to manufacture the Solar " Mars " 50 h.p. gas turbine, and has changed the name of the firm to Perkins Gas Turbines, Ltd.; manufacture of the " Mars " now takes place at Peterborough. An agreement with the Solar Aircraft Company of San Diego gives Perkins the exclusive rights in the British Commonwealth, excluding Canada, Europe, and Africa, to make and sell Solar gas turbines. The " Titan " of 70 h.p. and the T-150 of 170 h.p. are planned for production at Peterborough next year ; the 500 h.p. " Jupiter " (page 562, October 14, 1955) and the 1250 h.p. " Saturn " will be supplied from San Diego.

Contracts

HUMPHREYS AND GLASGOW, Ltd., has received a contract from the Okura Trading Company, Ltd., on behalf of the Kanazawa Gas Company, for the installation of two units of carburetted water gas plant, together with ancillary equipment. The plant will be capable of producing 400,000 cubic feet of town's gas per day from each of the two units.

DE HAVILLAND PROPELLERS, Ltd., has placed an order with E.M.I. Electronics, Ltd., for a large EMIAC II computer, as an additional aid to research into guided missiles and other problems associated with high-speed flight. The installation will consist of twenty-two modules and will cost £52,000.

CORRECTION : DIRECT-GAS-COOLED GENERATORS FOR KINCARDINE POWER STATION.—In the penultimate sentence of a Contracts announcement on page 516 of our issue March 27 there is an error in punctuation. The sentence should read " The generator rotors will have hollow conductors direct-cooled by hydrogen—the same arrangement as adopted for G.E.C. machines already in service with a hydrogen pressure of 30 lb per square inch." A pressure of 50 lb per square inch will, however, be used for the G.E.C. 200MW sets (for Kincardine power station) which are the subject of the contract referred to.

VERNONS INDUSTRIES, Ltd., is to supply to the British Overseas Airways Corporation twenty ground power units for use with Boeing " Jet-Stratoliner " and Vickers VC-10 aircraft at a cost of about £125,000 ; these include eight 25kW, 25kVA nominal 200/115V, three-phase, 400 c/s, four-wire sets, consisting of a brushless alternator with a.c. exciter, rotating rectifier and transistor A.V.R., driven by a Ford 4-cylinder diesel engine running at 1714 r.p.m. Transistor A.V.R.s have been so successful in service and testing that all Vernon's G.P.U.s energisers and motor/alternator sets will in future be controlled by them.

THE BRITISH TRANSPORT COMMISSION has placed orders valued at over £11,000,000 for 130 main-line diesel-electric locomotives for British Railways. Of these, fifty-five will be 2000 h.p., Type 4 1 Co-Co 1 locomotives built by the English Electric Company, Ltd., Marconi House, London ; and seventy-five will be 1365 h.p., A1A-A1A locomotives supplied by the Brush Electrical Engineering Company, Ltd., Loughborough, a member of the Hawker Siddeley Group. The Brush locomotives will have diesel engines by Mirrlees, Bickerton and Day and turbochargers by Hawker Siddeley Brush Turbines, Ltd. This is stated to be the largest single order for complete main-line diesel-electric locomotives to be placed with a private firm by the B.T.C. Both series of locomotives are repeat orders to the contractors concerned for similar units already in service. All will be geared for a top speed of 90 m.p.h. These contracts bring the total number of diesel locomotives ordered for main-line duties in connection with the railway modernisation programme to more than 1000. About 160 of the locomotives are already in service, and it is hoped that there will be nearly 500 by the end of this year. The 130 locomotives now ordered will be allocated to Regions on delivery, beginning in December this year and continuing until the end of 1960.

Miscellanea

DUSTON MILL PUMPING STATION.—The inauguration of the Mid-Northamptonshire Water Board's Duston Mill Works was reported in our issue of April 24, on page 663. We are informed that the main contractor for the pumping station was A. Monk and Co., Ltd. ; this firm also carried out the pipelaying as a separate contract.

" TROJAN " PRODUCTS DISPLAY.—A display of its products was staged last week by Trojan, Ltd., at Purley Way, Croydon. The motor vehicles included a rural bus, a fourteen-seater, which the company has recently introduced. The bus is built to the Ministry of Transport passenger service vehicle standards on the " Trojan " 25 cwt chassis with a Perkins P3 engine. In a section of the display allocated to the Trojan agricultural division, the " Airator " mobile dryer (THE ENGINEER, December 6, 1957) was shown at work, as was the " Clinton " chainsaw which is operated by a two-stroke engine.

DIGITAL COMPUTERS.—A Kodakchrome film entitled " Time to Think," made for International Computers and Tabulators, Ltd., by Cinechrome, Ltd., was shown recently in London. The film concentrates on presenting the economic case for the electronic computer from the prospective users' point of view, and poses questions which an organisation interested in the potentialities of the computer must face. It answers these questions by illustrating the experiences of a hypothetical manufacturing firm from the moment it decides seriously to investigate the possible uses of a computer to the time it takes delivery of a machine. Throughout the film, emphasis is placed upon the solution of management problems that arise in the users' organisation. The film runs for forty minutes and is available on free loan in 16mm size.

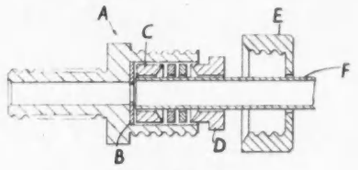
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings, unless otherwise stated. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

TUBE COUPLINGS

811,077. March 8, 1957.—FLUID-TIGHT TUBE COUPLINGS, Tri-Sil (Chemicals and Equipment), Ltd., 79–81, Nile Street, London, N.1. (*Inventors: Montague Peters, Robert Arthur Cole and Alan Walsh.*)

The invention relates to a fluid-tight tube coupling which is particularly, although not exclusively, suitable for securing the end of a glass tube to, for example, a container, and which will withstand high fluid pressures without leaking. A preferred embodiment of the tube coupling is described with reference to the



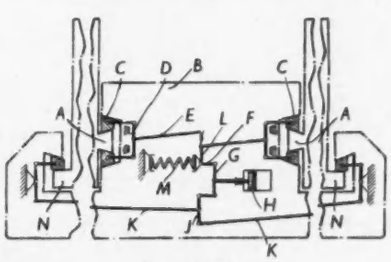
No. 811,077

accompanying drawing. The coupling comprises an axially bored member *A* with two externally threaded portions having small and large bores respectively so that an annular shoulder is formed at the junction of the two bores. A resilient washer *B* in the larger bore is preferably made of neoprene or plastic. An inner cylindrical sleeve *C* has an inwardly bevelled end and two resilient sealing rings may also be of neoprene or plastic. An inner cylindrical sleeve *D* having a flange has an inwardly bevelled end and is pushed into the body by an internally threaded cap *E*. When a glass tube *F* is secured to the body the tightening of the cap on the member squeezes the resilient washer B between the shoulder and the inner sleeve *C*, making a first seal at this point, and squeezing of the resilient rings between the two bevelled rings produces another seal. A third seal is provided between the bevelled surfaces of the inner sleeve and the ring *B*. The sleeves and the cap are a free sliding fit on the tube *F*, and this, coupled with the fact that the two rings are resilient, permits the tube to move slightly with respect to the member *A*. When the joint is subjected to stresses such as vibration, leakage around the resilient rings is thus prevented.—*April* 2, 1959.

MACHINE TOOLS

811,164. April 4, 1955.—MEANS FOR CLAMPING THE CROSS BEAM ON DOUBLE-COLUMN MACHINE TOOLS, H. A. Waldrich, G.m.b.H., Siegen/Westfalen, Germany.

The invention is described with reference to the accompanying diagrammatic drawing, which is a plan view of part of a two-column planing machine. The columns on their inner surfaces have holding ribs *A* of dovetail profile. On the cross beam *B* two pairs of wedge bars *C* have inner surfaces which correspond



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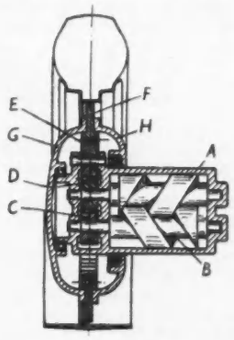
to the profile of the holding ribs, while their outer surfaces are of wedge form and are guided by corresponding counter-surfaces on the cross beam. The wedge bars are connected by rods to a lever D having two equal arms, the movement of which is limited by stops. The mid-point of each lever D is in each case connected to a pull rod *E* independently of the cross beam. The ends of the pull rods near the centre of the cross beam are pivotally connected to the end and the mid-point of a lever *L* which, through a rod *F*, is connected to a corresponding double lever *G*. The mid-point of this lever *G* is pivoted to the piston-rod of a hydraulic cylinder *H*. The other end of the lever *G* is connected by a rod with another double lever *J*. The middle and the other end of *J* through connecting-rods *K* is connected to clamping points arranged at the ends of the cross beam. The clamping arrangements at these points consist of holding ribs on the columns, and wedge bars, slidably mounted on the cross beam, which are actuated through pull rods and levers. Against the double lever *L* to which the clamping assemblies on the inner holding ribs are connected is a compression spring *M* which provides a preload to give a preliminary clamping *N* on the two outer ribs, so that the beam is first lightly clamped here before all the clamps are simultaneously actuated by the piston-rod.—*April* 2, 1959.

HYDRAULIC ENGINEERING

811,271. January 21, 1957.—INTERMESHING SCREW ROTARY MOTORS, Veb Schlepperwerk Nordhausen, Freiherr-vom-Stein-Strasse 30c, Nordhausen, Harz, Germany.

The invention relates to intermeshing screw rotary motors, which may be used primarily for the driving of vehicles. In the embodiment shown, a single



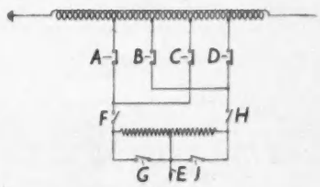
No. 811,271

hydraulic driving unit comprises two intermeshing screws *A* and *B* rotatably mounted in a casing. At one end, the shafts of the screws extend out of the housing and carry meshed gears *C* and *D*, which, in use, are driven by the screws in opposite directions. A gear wheel *E* engages on the innerside in the gear *D* and on the outer side in a toothed rim *F*. The toothed rim is centrally secured between two curved discs *G* and *H*, which are rotatably mounted on the casing by ball bearings. By this arrangement a closed space is formed which is partially filled with oil and serves for the lubrication of the gears and of the ball bearings. On the outer periphery of the toothed rim there can be secured a rim with a rubber tyre or a belt pulley. A further possibility of use, which has not been shown, consists in that on the disc *G* there is attached a shaft stub provided with splines, so that the motor may alternatively be used as a power take-off shaft drive arrangement for agricultural equipment on tractors. As driving medium there is predominantly used hydraulic oil delivered by a pump. The specification also describes arrangements of hydraulic motors for driving large wheels of tractors, vehicles or locomotives.—*April* 2, 1959.

ELECTRIC TRACTION

811,226. February 21, 1957.—TAP CHANGING APPARATUS, The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. (*Inventor: James Charles Turrall.*)

The present invention relates to tap changing apparatus for association with a tapped winding of a transformer, and particularly to apparatus for tap changing on the high tension side while on load. Its object is to provide a simplified tap changing apparatus in which the number of transitional operations is small and the work to be done is distributed



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sufficiently evenly between contacts to reduce wear. The accompanying circuit diagram shows a transformer, as may be employed in alternating current traction arrangements, the high tension winding being connected between an overhead supply line and earth. Each tapping is connected to a non-current-making or breaking switch, *A*, *B*, *C*, *D*, which may be cam-operated contacts, or sliding contacts. Switches *A* and *C* or *B* and *D*, form two series, the switches in each being connected together on the side remote from the winding. Thus, tappings are connected through switches *A* and *C* to a common point, and this point has a contactor arrangement connected between it and the main output lead *E*. The contactor arrangement consists of two series-connected contactors *F* and *G* with a suitable impedance, connected as a shunt across the contactor *G*, from which the main output lead is taken; the paths from the two tappings are then through switches *A* or *C*, *F* and then *G* to the output lead. Similarly, paths from the other two points on the transformer lie through switches *B* or *D*, a contactor *H* and a further contactor *J* shunted by an impedance to the common output lead. The contactors *F*, *G*, *H*, *J* are air break contactors operated from the same mechanism as the switches *A*, *B*, *C* and *D*. The following sequence illustrates a change from the tapping connected to switch *A* to that connected to switch *B*.

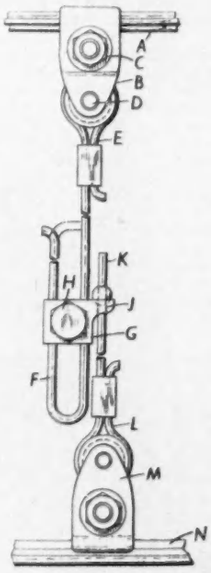
Step	Switches	Contactors
1	*A*	*F, G*
2	*A, B*	*F, G*
3	*A, B*	*F, G, H*
4	*A, B*	*F, H*
5	*A, B*	*H*
6	*B*	*H, J*

In the specification the sequence is continued through the remaining tappings.—*April* 2, 1959.

RAILWAY ELECTRIFICATION

811,230. June 28, 1956.—CONDUCTOR WIRE SYSTEMS, Aktiengesellschaft Kummler and Matter, 176, Hohlstrasse, Zürich, 26, Switzerland.

In the arrangement according to this invention, each suspension wire of an electric railway conductor wire consists of at least two parts pivotally connected respectively to the support cable and to the conductor wire and coupled by an adjustable connector. As shown in the diagram, *A* indicates the support cable to which a clamp *B* is fastened by means of a bolt *C*. The two jaws of the clamp support a pin *D* on which an eyelet *E* of the upper suspension wire is supported



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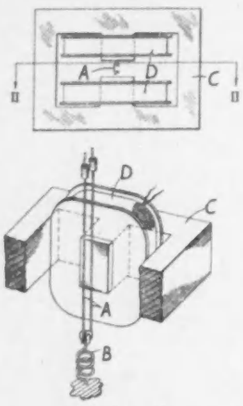
directly. The lower end of this part of the suspension wire is formed into a loop *F* on which a two-part clamp *G* is fastened by means of a set screw *H*. This clamp further comprises a guide *J* through which the lower part *K* of the suspension wire can slide. The lower end of this part of the suspension wire is also formed as an eyelet *L*. A clamp *M* is used for pivotally connecting this eyelet with the conductor wire *N*. By this arrangement, the distance between the support cable and the conductor wire can be varied without substantial effort by displacement of the clamp *G* on the loop *F*. The adjusted length of the suspension wire can be held by means of the set screw *H*. If the conductor wire is raised more than the support cable by the action of the current collector, the part *K* of the suspension wire slides within the guide *J* of the clamp *G*. By this arrangement, rapid adjustment of the length of the suspension wire can be obtained and, further, the conductor wire is loaded by the device to the minimum extent, so that there is minimum variation of the contact pressure.—*April* 2, 1959.

ELECTRICAL ENGINEERING

811,657. May 30, 1957.—A.C./D.C. Converter, United Kingdom Atomic Energy Authority, London. (*Inventor : Frank Aughtie.*)

This invention relates to methods and apparatus for converting small unidirectional e.m.f.s into related alternating quantities which can be amplified for measurement. In its operation a unidirectional e.m.f. is converted to a related alternating quantity by its application to a vibrant conductor supported in a transverse a.c. magnetic field. The upper drawing is a plan view of one form of the invention and the lower one a perspective section on the line II-II. A bifilar wire *A* is tensioned by a spring *B* in an alternating field given by a core system *C* and coil winding *D*. For some applications the alternating field may be provided by connecting the coil to the ordinary

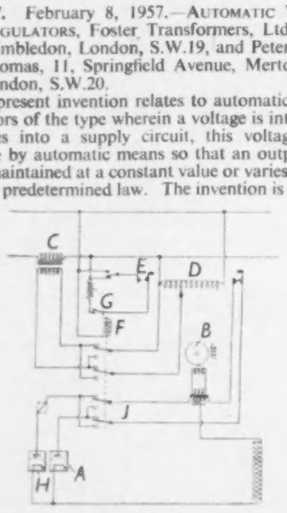


No. 811,657

50 c/s supply mains. When this is done it may be necessary to broaden the frequency response of the vibrating wire by applying damping to it either by immersing it in a suitable medium or by connecting a damping resistance across it. If the supply mains are not available, or are unsuitable, the supply for the coil can be obtained from a suitable oscillator and valve amplifier. Special arrangements may then be necessary to maintain resonance between the natural frequency of the wire and the frequency of the field. Alternatively, the oscillator can comprise a wire maintained in self-oscillation, by means already known, the wire being of the same material and dimensions as that used in the main device, and subjected to the same tensile load. To avoid the need for filters to separate the d.c. input and a.c. output circuits, use can be made of the fact that for the same direction of d.c. flow through similar wires the instantaneous a.c. induced e.m.f.s are in the opposite direction if the wires are placed in two separate a.c. magnetic fields in time quadrature. Two circuits for doing this are shown in the specification.—*April* 8, 1959.

811,017. February 8, 1957.—Automatic Voltage Regulators, Foster Transformers, Ltd., South Wimbledon, London, S.W.19, and Peter George Thomas, 11, Springfield Avenue, Merton Park, London, S.W.20.

The present invention relates to automatic voltage regulators of the type wherein a voltage is introduced in series into a supply circuit, this voltage being variable by automatic means so that an output voltage is maintained at a constant value or varies according to a predetermined law. The invention is directed



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to increasing the range of the regulating transformer by associating it with a reversing switch including two simultaneously movable contacts controlling the sense of the variable voltage injected into the load circuit. These are operable in a terminal position of adjustment of the transformer so that two successive traverses correspond to a change from maximum boost or buck to zero boost or buck and then an increase from zero to maximum buck or boost respectively. Referring to the diagram, if the input voltage rises, the gas-filled discharge device *A* controlling the bucking action will operate, causing rotation of the regulating transformer drive motor *B* in a direction which may be assumed initially to represent a reduction in the boosting action of the series buck-and-boost transformer *C*. If the regulating transformer *D* reaches its minimum travel limit, the normally open limit switch contact *E* is closed at the point where the minimum boost voltage is applied to the series transformer *C*. The limit switch causes operation of the relay *F* and contact *G* holds this relay operated. The connections from *D* to *C* are reversed so that *C* acts as a bucking transformer with a progressively increasing effect as the voltage on *D* is increased. At the same time the connections to the two gas-filled discharge tubes *A* and *H* are reversed by contacts *J*, so that, assuming the input voltage continues to increase, the same discharge tube as before remains operative but the drive motor is reversed. Consequently, the regulating transformer brush or tapping is moved in the opposite direction, thereby giving a further range of voltage adjustment. —*March* 25, 1959.

Launches and Trial Trips

Mystic, cargo ship ; built by the Burntisland Shipbuilding Company, Ltd., for the Johnson Warren Line ; length between perpendiculars 450ft, breadth moulded 63ft 3in, depth moulded to upper deck 39ft 6in, deadweight 10,685 tons on 26ft 8in draught ; five holds, one 50-ton, four 10-ton and twelve 5-ton derricks, electric winches ; four 160kW diesel-driven generators ; Hawthorn-Doxford, six-cylinder oil engine, 8000 b.h.p. at 115 r.p.m. Trial, March.

Sougueta, banana carrier ; built by the Chantiers Reunis Loire-Normandie, Quevilly ; length between perpendiculars 344ft 6in, breadth moulded 50ft 6½in, depth to shelter deck 34ft 7in, maximum deadweight 4180 tons, load deadweight 2280 tons, load displacement 7120 tons ; four holds, speed 16 knots ; l'Atlantique-Burmeister and Wain Mark 762VTBF diesel engine, 620mm bore by 1150mm stroke, 5750 b.h.p. at 150 r.p.m. Trial, March.

Rosebank, cargo ship ; built at Belfast by Harland and Wolff, Ltd., for Andrew Weir and Co., Ltd.; length between perpendiculars 450ft, breadth moulded 62ft 6in, depth moulded to upper deck 38ft 6in, gross tonnage 6500 (open shelter deck), 8700 (closed shelter deck) ; two complete steel decks, eight watertight bulkheads, five main holds, one 25-ton, two 10-ton, twelve 5-ton and two 3-ton derricks, fourteen electric winches ; three 175kW diesel-driven generators ; Harland and Wolff, two-stroke, single-acting, opposed-piston diesel engine, six-cylinders 620mm diameter by 1870mm combined stroke, 118 r.p.m. Trial, April 3.

Machaon, cargo liner ; built by the Caledon Shipbuilding and Engineering Company, Ltd., for Alfred Holt and Co.; length overall 495ft, breadth moulded 65ft, depth moulded to upper deck 36ft, deadweight 9800 tons, sea speed 15 knots ; six cargo holds, one 35-ton, two 15-ton, six 10-ton, eighteen 5-ton derricks, twenty-four electric winches ; three 330kW and one 150kW diesel-driven generators ; exhaust turbo pressure charged, single-acting diesel engine, 8500 b.h.p. at 115 r.p.m. Trial, April 9.

Catalogues and Brochures

Charles Carr, Ltd., Grove Lane, Smethwick, 40.—Price list for non-sparking tools.

G. Brady and Co., Ltd., Manchester, 4.—Illustrated folder describing flexible rubber doors.

Voucher, Ltd., Walsall, Staffs.—Leaflets describing the "Voucher 57" pneumatic twin-saw and single-saw machines.

Q.V.F., Ltd., Duke Street, Fenton, Stoke-on-Trent.—Leaflet giving details of a new erection service developed by the company.

Morgan Refractories, Ltd., Neston, Wirral, Cheshire.—Leaflet introducing "Purox" oxide refractories of high chemical purity.

Don Valley Engineering Company, Ltd., Wheatley Lane, Doncaster.—Illustrated brochure describing "Weatfal" resonance screens.

Manufacturers Equipment Company, Ltd., Sutton Road, Hull.—Information sheet No. 757/18, describing the "Rapistan I.R." live roller conveyor.

C. C. Wakefield and Co., Ltd., 46, Grosvenor Street, London, W.1.—Illustrated brochure stressing the correct use of lubricants for mechanical equipment.

R. F. Landon and Partners, Ltd., David Road, Poyle Trading Estate, Colnbrook, Bucks.—Illustrated leaflet giving details of a fire valve switch.

Midland Silicones, Ltd., 68, Knightsbridge, London, S.W.1. —Booklet describing some of the properties and applications of silicone resin bonded glasscloth laminates.

Amplivox, Ltd., Industrial Division, Beresford Avenue, Wembley.—Illustrated leaflets describing fully tropicalised miniature earphone and microphone insets.

A. A. Jones and Shipman, Ltd., 50/52, Great Peter Street, London, S.W.1.—List No. 253, giving complete technical details of model "1049" production cylindrical grinder.

Clarkson (Engineers), Ltd., Nuneaton.—Catalogue and price list describing standard parallel shank and taper shank twist drills made from high-speed steel to B.S. 328/1950.

Imperial Chemical Industries, Ltd., Nobel Division, 25, Bothwell Street, Glasgow, C.2.—Booklet dealing with the construction and range of safety fuses supplied by the company. A table is included listing some typical examples of fuses with burning speeds and conditions under which they are intended to be used.

Standard Telephones and Cables, Ltd., Connaught House, Aldwych, London, W.C.2.—Leaflet L/102, giving brief technical specification and some programming features of the "Stantec Zebra" electronic digital computer. Technical data sheet MF/105, describing silicon rectifier stacks incorporating RS3 and RS5 series silicon junction power rectifiers, and leaflet MF/104, describing high-stability carbon resistors, designed to maintain their resistance values within close limits under varying conditions of load and temperature.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings, inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Sat., May 30.—Wolverhampton and District Branch : Chamber of Commerce, District Bank Chambers, Lichfield Street, Wolverhampton, Branch Annual General Meeting, 7 p.m.

CHEMICAL SOCIETY

Thurs., June 4.—Burlington House, Piccadilly, London, W.1, "Kinetics and Orientation of Some Epoxide Ring Opening Reactions," N. B. Chapman, N. S. Isaacs and R. E. Parker ; "Aromatic Reactivity : Part III, Cleavage of Substituted Phenyltrimethylsilanes by Sulphuric Acid in Acetic Acid-Water," F. B. Deans and C. Eaborn ; and "The Heats and Entropies of Ionisation of Some Aromatic and N-Hetero-aromatic Amines," J. J. Elliott and S. F. Mason, 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., June 9.—Great George Street, Westminster, London, S.W.1, Annual General Meeting, 5.30 p.m.

Wed., June 17.—Great George Street, Westminster, London, S.W.1, Conversazione, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon. to Fri., June 15 *to* 19.—Summer Meeting at Harrogate.

INSTITUTION OF MECHANICAL ENGINEERS

Mon. to Fri., June 29 *to July* 3.—Summer Meeting in Switzerland.

INSTITUTION OF PRODUCTION ENGINEERS

Sat., June 6.—North Midlands Region : Ericsson Telephones, Ltd., Beeston, Nottingham, One-day Conference, "Communication of Ideas in Production—Its Importance and Improvements."

Thurs. and Fri., June 18 *and* 19.—Palace Hotel, Buxton, Joint Conference to be held in conjunction with the Institution of Engineering Inspection and the British Productivity Council, "Quality in Industry."

INSTITUTION OF PUBLIC HEALTH ENGINEERS

Fri., June 19.—Caxton Hall, Westminster, London, S.W.1, Annual General Meeting, 4.45 p.m., and "New Headworks and Reservoir, Hanningfield," W. C. Young and G. Davis, 6 p.m.

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Tues. to Sat., June 23 *to* 27.—The University, St. Andrews, Scotland, Third Annual Conference.

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To-day, May 29, *to Fri., June* 19.—Engineering Laboratory, University of Cambridge, Trumpington Street, Cambridge. Exhibition to commemorate the Centenary of the death of Isambard Kingdom Brunel, 9 a.m. to 5 p.m. ; Sats., 9 a.m. to 12 noon.

WOMEN'S ENGINEERING SOCIETY

Wed., June 10.—"Hope House," 45, Great Peter Street, Westminster, London, S.W.1, Annual General Meeting, 7 p.m.

Advanced Engineering Courses

Techniques of Non-Destructive Testing. Physics Department, Brunel College of Technology, Woodlands Avenue, Acton, London, W.3. Course of ten lectures, Wednesday evenings from 7 p.m. to 8.30 p.m., commencing October 7. Fee £1.

The Application of Work Study. Institute for Engineering Production, University of Birmingham, 16, Norfolk Road, Edgbaston, Birmingham, 15. The primary purpose of the course is to examine work study theory and research and its practical application as the direct approach to increasing industrial productive efficiency, by the more effective employment of existing equipment, materials and personnel. The course will be held from 9.30 a.m., Monday, June 8, until 3.30 p.m., Friday, June 19. The inclusive charge for the two-week residential course is 55 guineas.

Postgraduate Course in Nuclear Technology (Chemical). Imperial College of Science and Technology, South Kensington, London, S.W.7. The object of the course is to provide a general training in the chemical and metallurgical aspects of nuclear technology, interpreted in a wide sense. The course is intended for graduates in chemical engineering, chemistry and metallurgy and is also available to suitably qualified applicants from industry. It is full-time and of one year's duration, starting in October. Fee £64.

Road Materials and Construction. Road Research Laboratory, Harmondsworth, Middlesex. Lecture courses will deal with the fundamental properties of road materials, and with the results of research and their application in modern practice. Courses will be held as follows :—"Concrete," September 29 to October 8, Course No. 29C ; October 13 to October 22, Course No. 30C ; "Bituminous (Including Tar) Materials," October 26 to November 6, Course No. 29B ; November 9 to November 20, Course No. 30B; "Soil Mechanics," November 24 to December 1, Course No. 29A ; December 8 to December 15, Course No. 30A. Fee for each course 12 guineas.

"Pre-Determined Motion Time Systems—II, Work Factor." Institute for Engineering Production, University of Birmingham, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. Residential executive course, June 22 to July 10. Fee 105 guineas.

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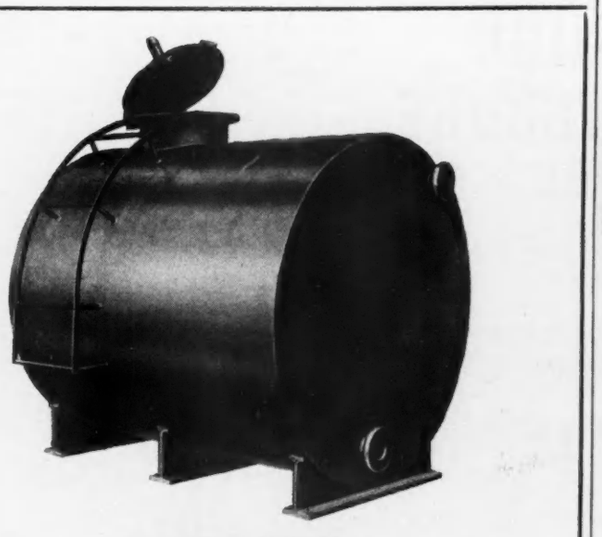

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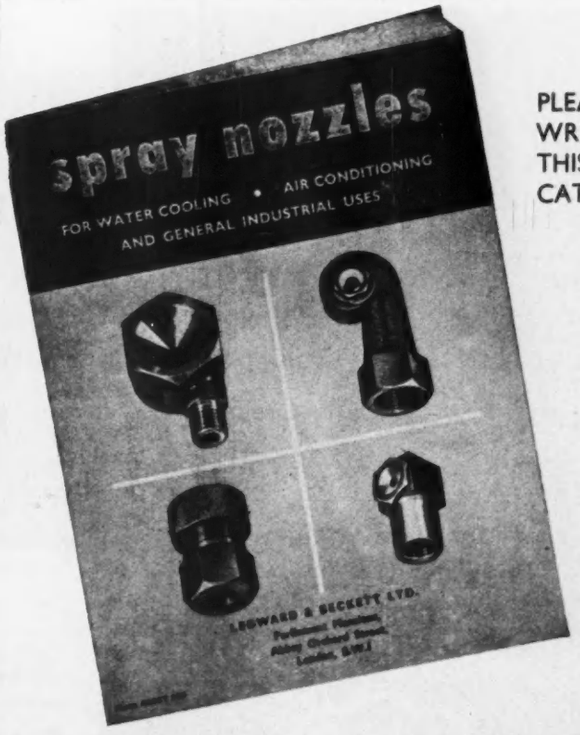

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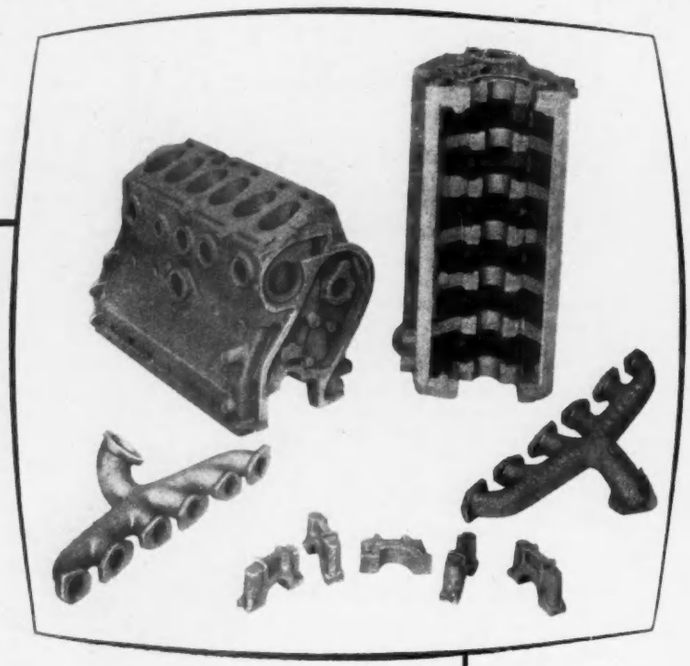

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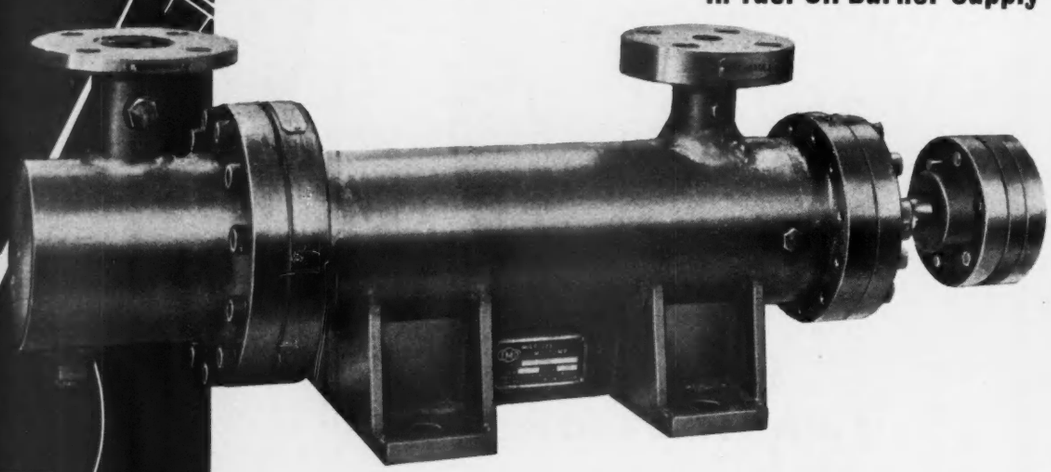

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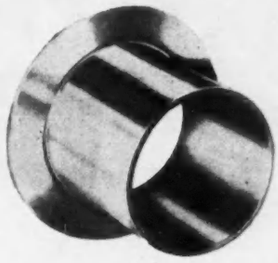

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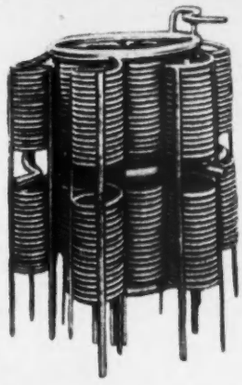

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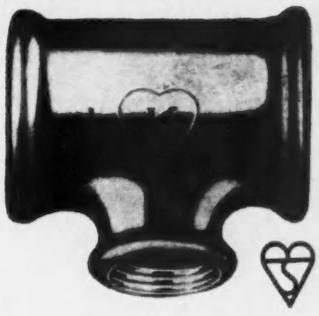

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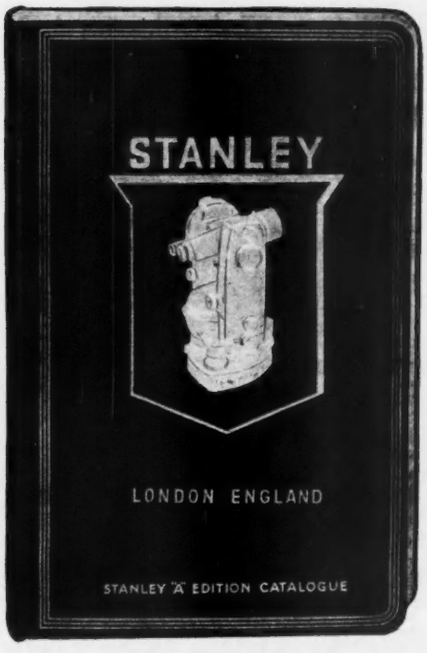

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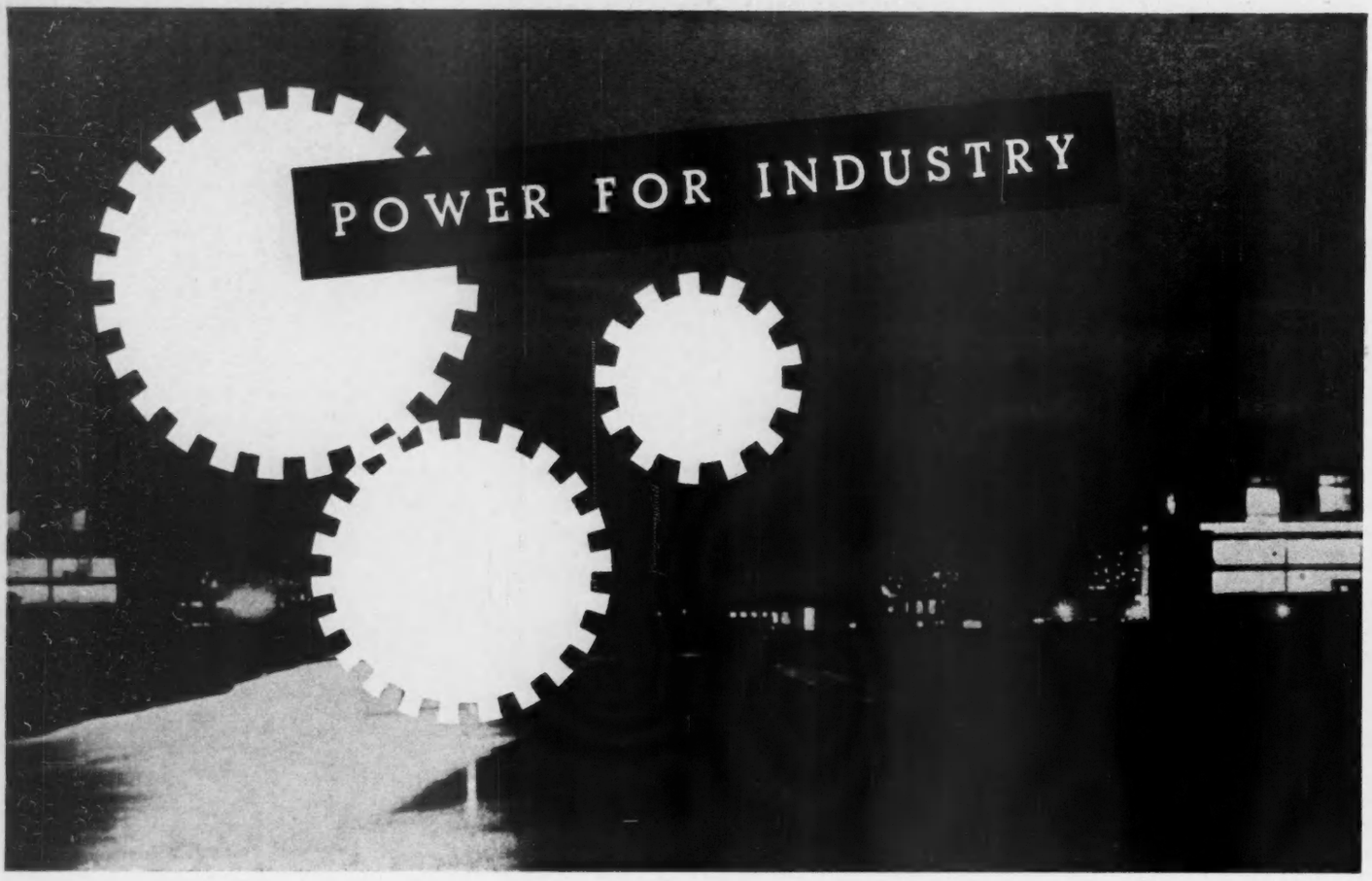

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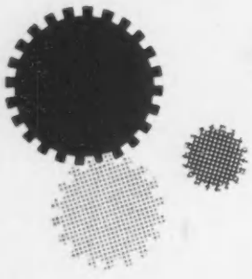

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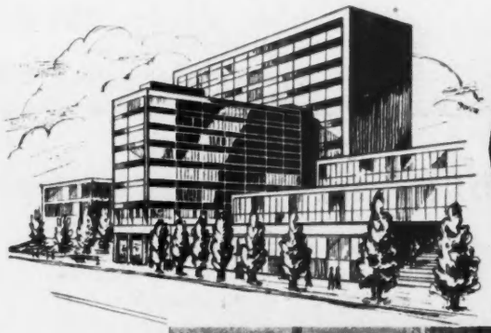

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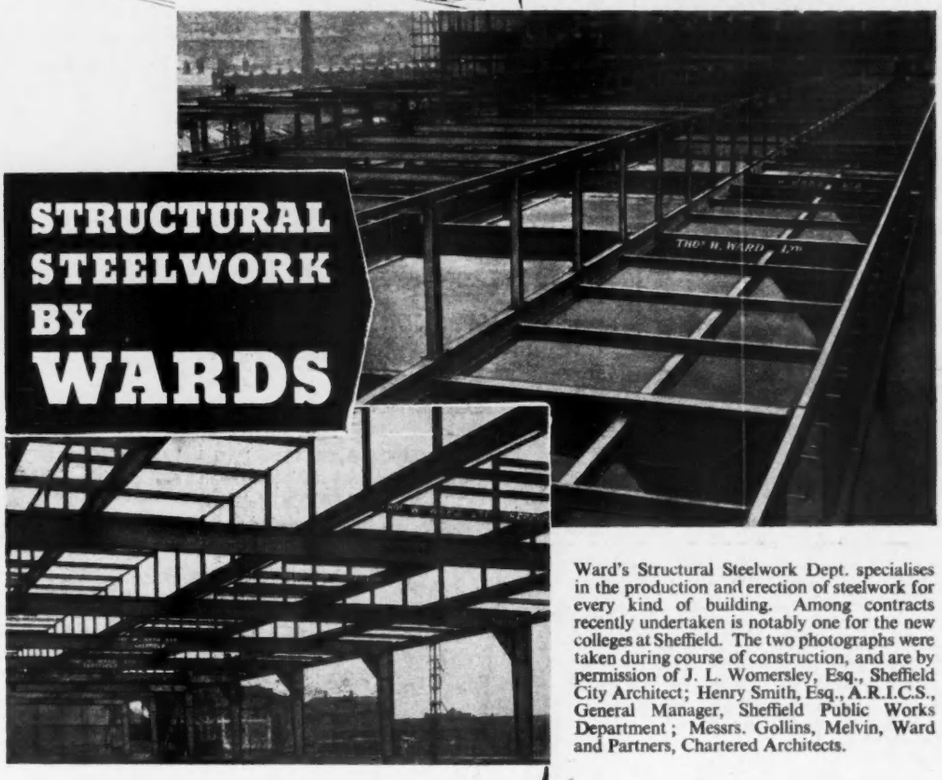

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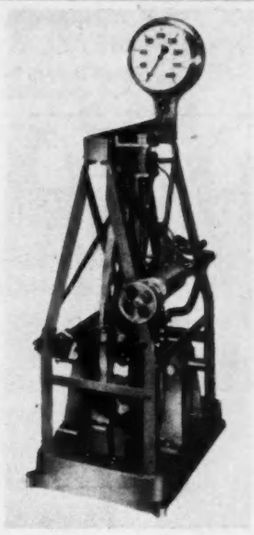

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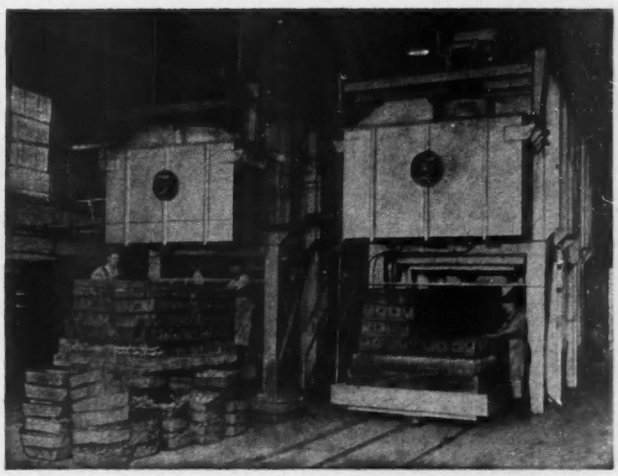

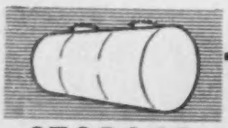

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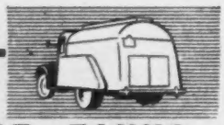

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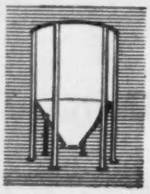

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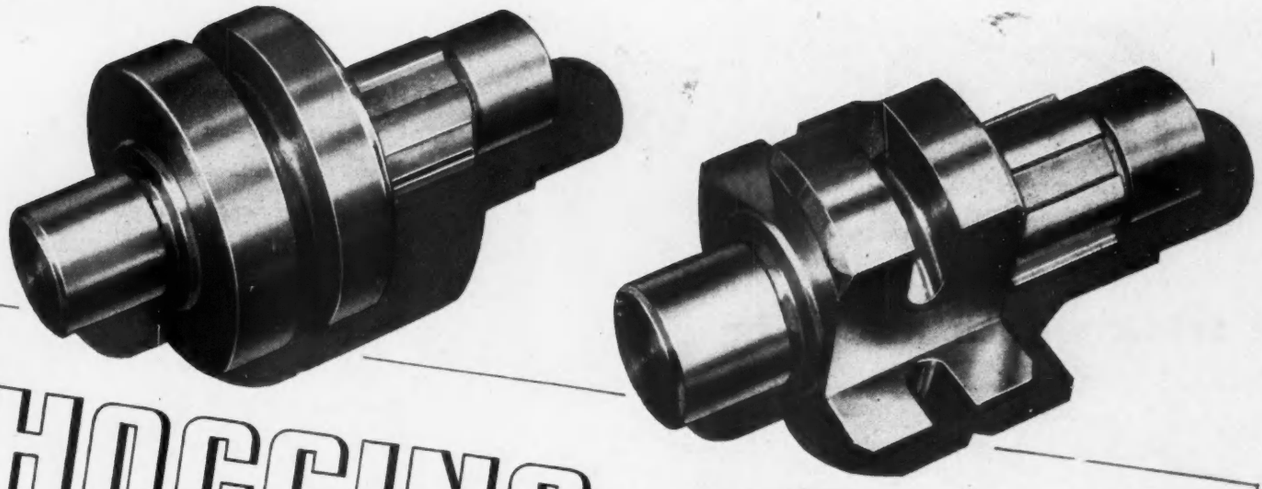

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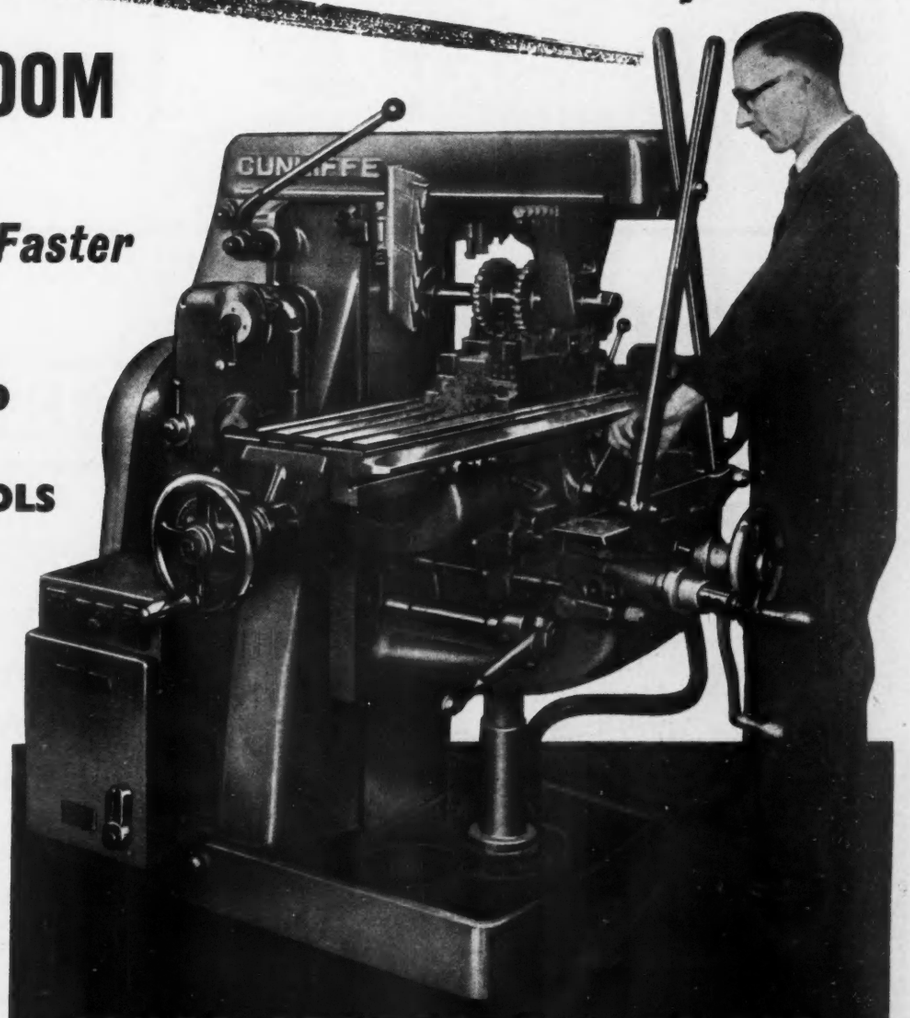

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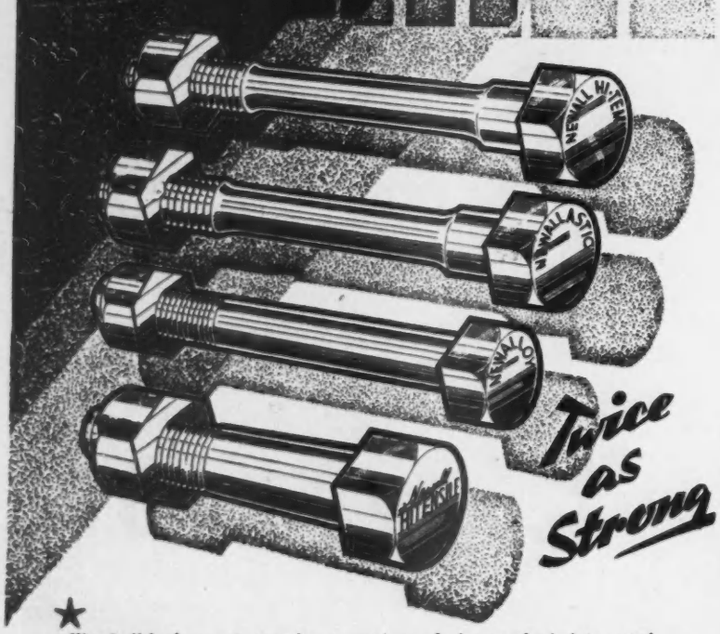

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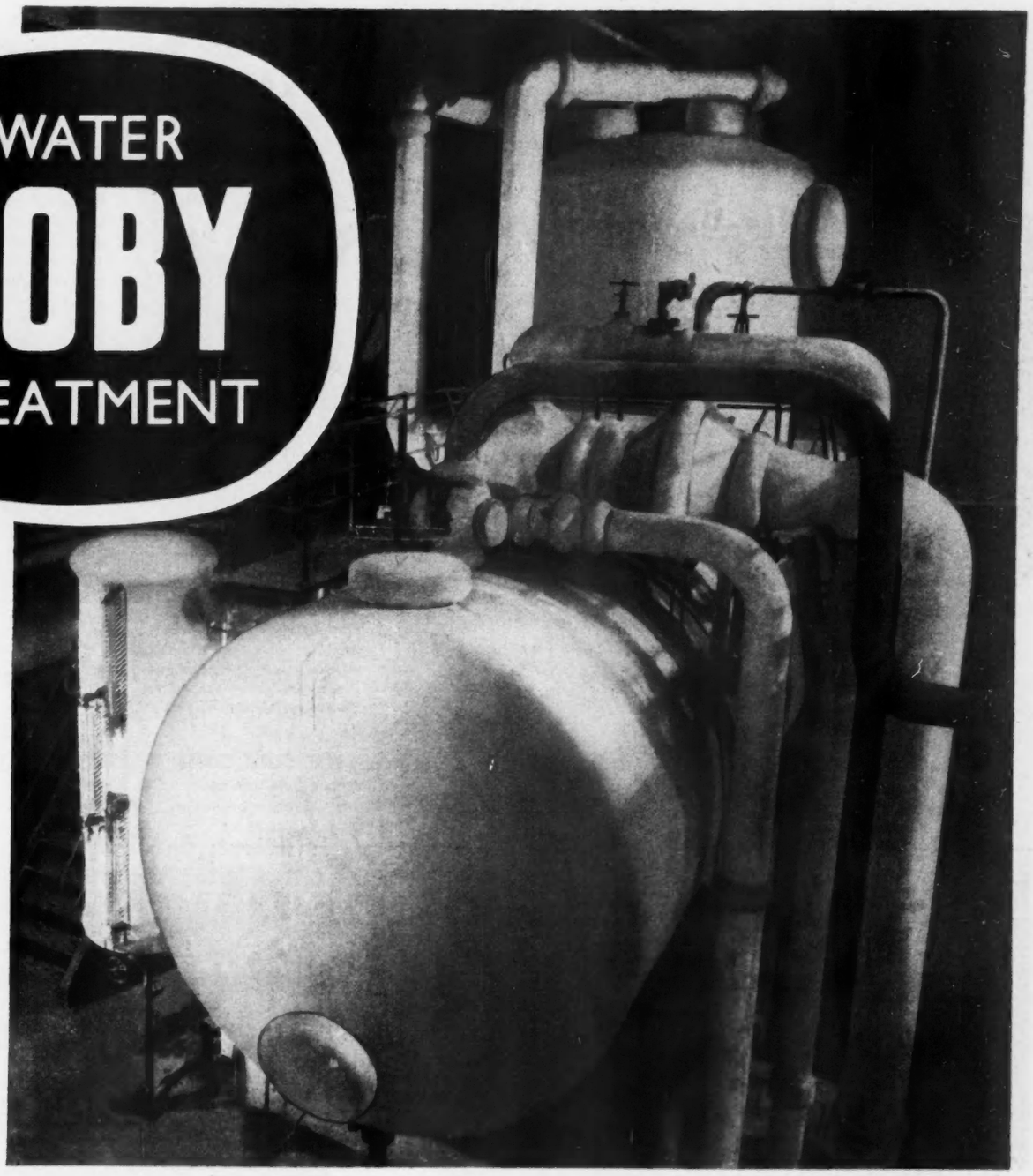

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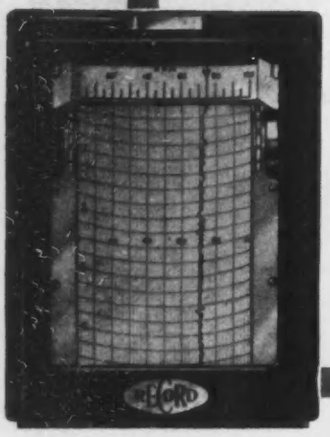

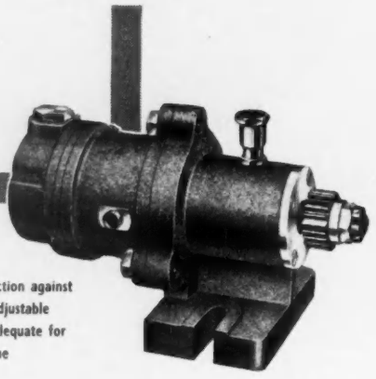

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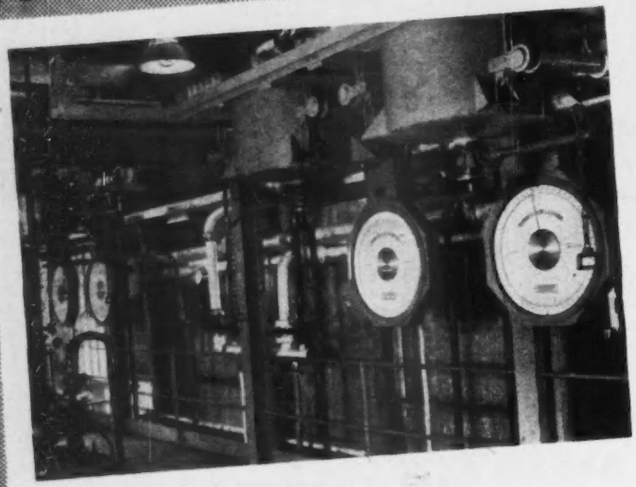

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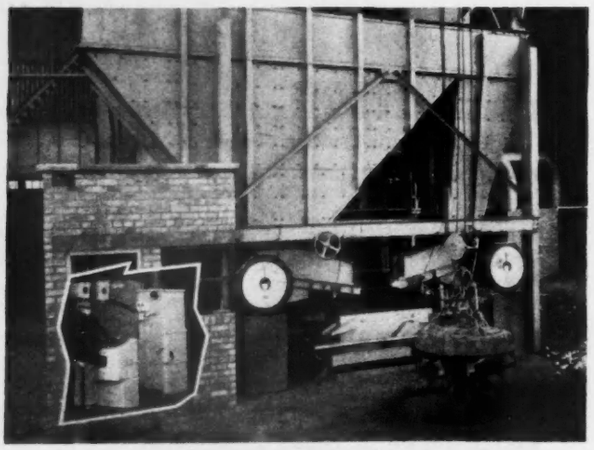

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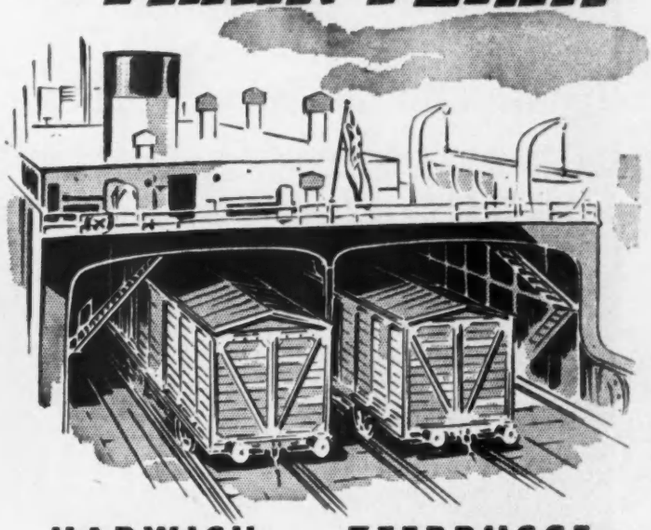

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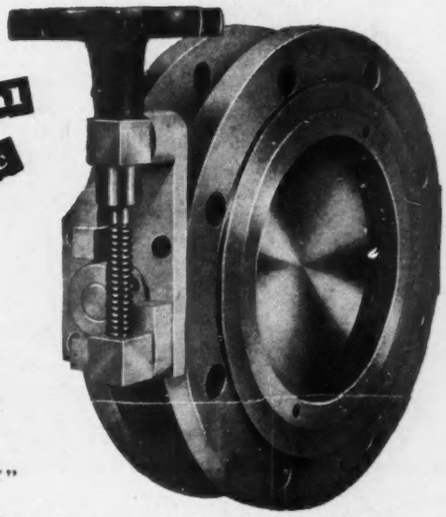

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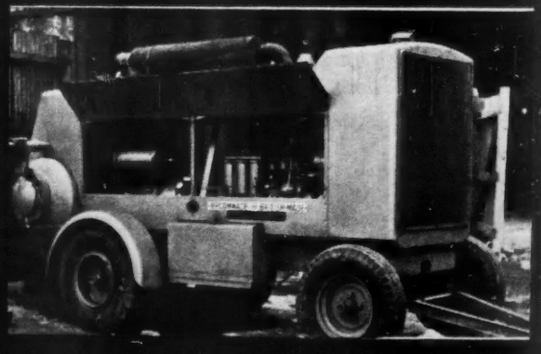

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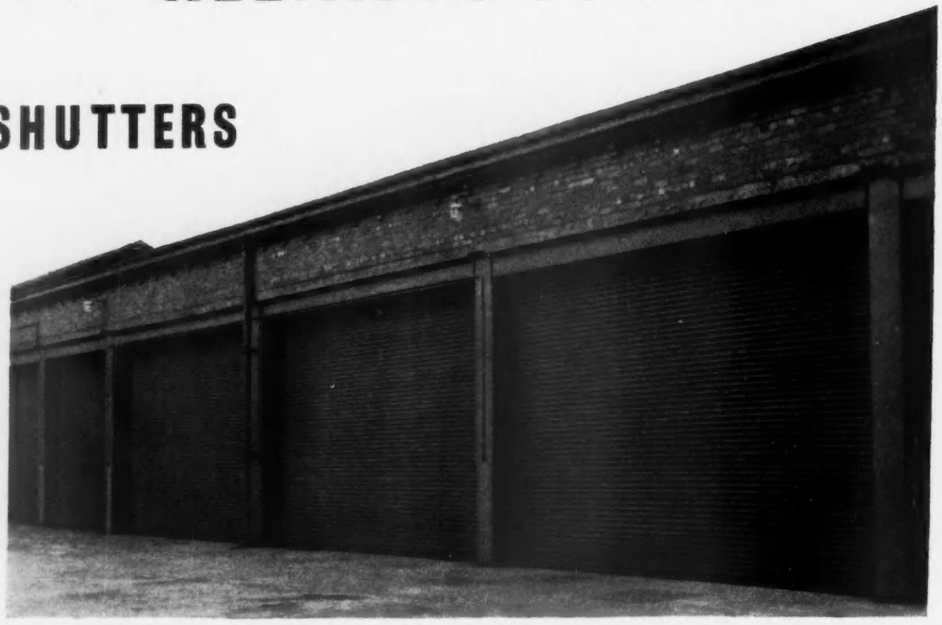

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This illustration shows the main moulding from Beetle D.M.C. and a retaining piece made from Scarab material. The Earguards are used in engine testing, rivetting, blasting, rolling mills, weaving sheds, paper mills and on aerodromes.

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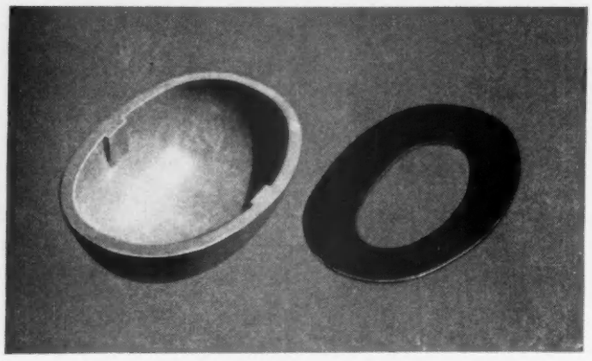

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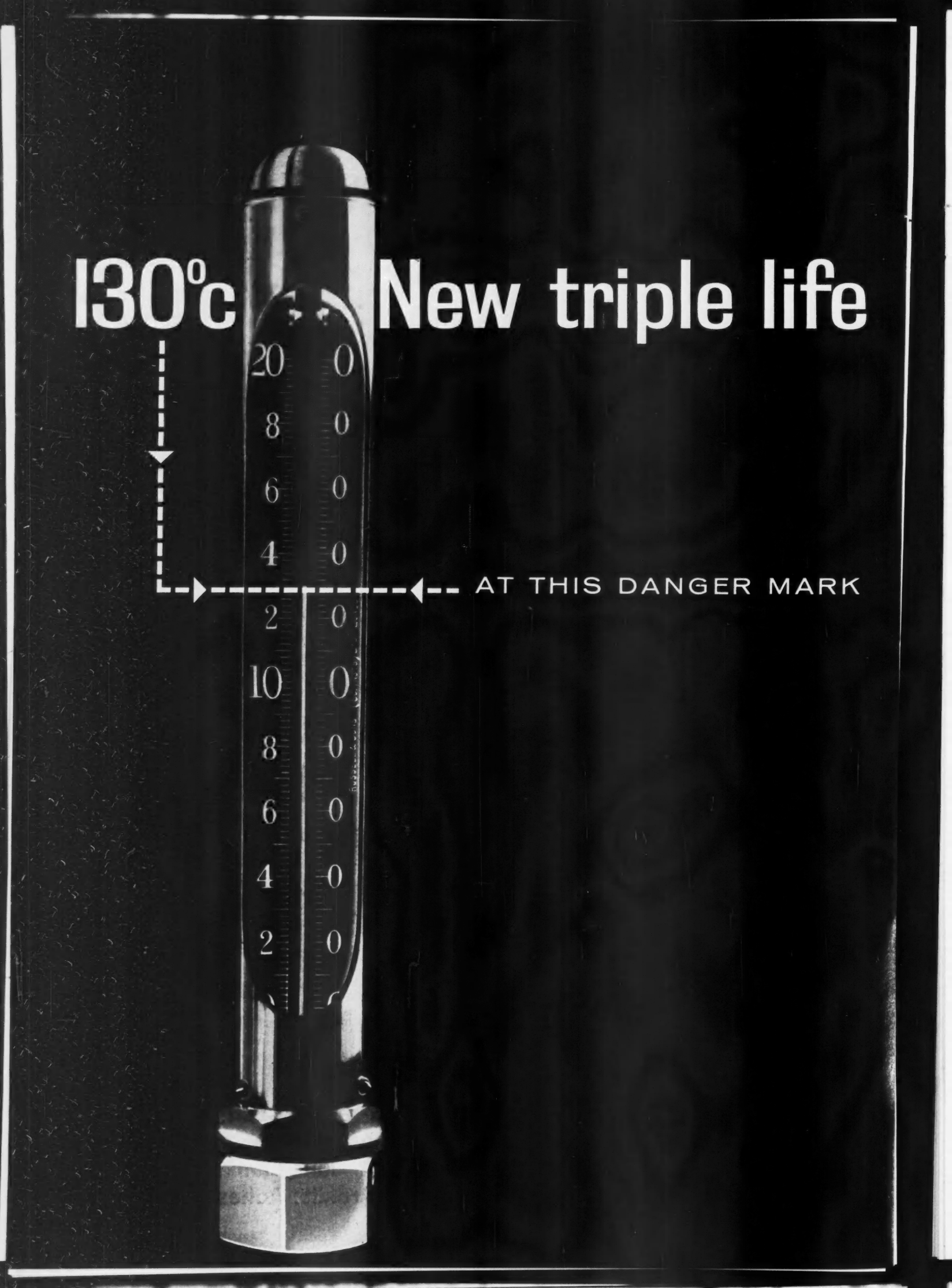
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First problem was the *length of life of the grease charge* at the higher running temperatures of some modern machines. Could this life be lengthened? Shell scientists, through new Shell Alvania, have given an emphatic answer – at 130°C., the danger mark where most greases fail quickly through dynamic oxidation, Shell Alvania will live three times as long.

The second associated problem was oxidation promoted by yellow metal cages. Could this be reduced? The answer, in Shell Alvania, is the virtual suppression of the effects of yellow metal.

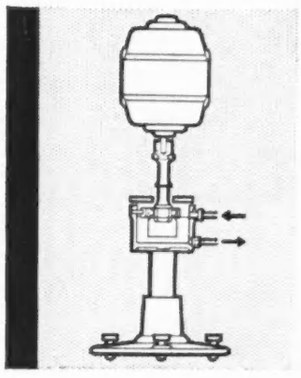
Problem three was corrosion caused by moisture. Could this be prevented? The answer was given in the Thornton Wet Bearing Rig Test*, where new Shell Alvania won an anti-corrosion rating of 10 out of 10.

New Shell Alvania greases were put on the market in March, 1957, and already, as proof of their success, tens of thousands of new electric motors leave British makers' works each week with Shell Alvania greases in their bearings.

What is the moral of the Shell Alvania story? That Shell research is supremely applicational. The centre at Thornton is always ready to work with even the most specialised sectors of industry to produce the right grease for the job. If you and your organisation have any major lubrication problems, it will pay you to get in touch with your local distributor of Shell Industrial Lubricants.

The Research Story

* In the Thornton Wet Bearing Rig Test water was fed through a 20 mm. bore bearing with a special demountable plastic cage (to simplify inspection) charged with the grease under examination to a weighed quantity rotating at 3,000 r.p.m. The rate of supply of water was one gallon per minute, the water running to waste. After 5 hours' operation the bearing was removed and stored horizontally half immersed in water for three days. Anti-corrosion merit ratings were given at the end of the test. High-quality greases without special protectives showed an average rating of 3 out of 10, while new Shell Alvania rated 10 out of 10.



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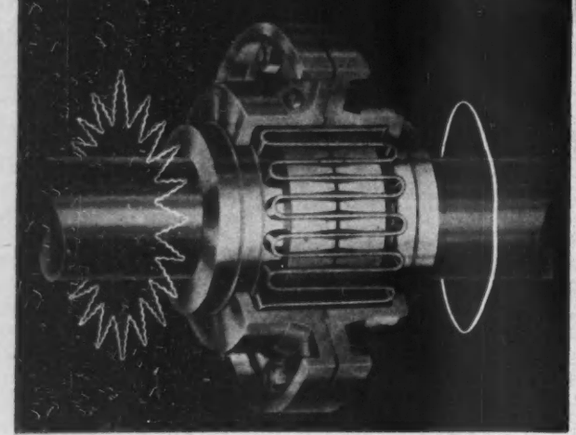

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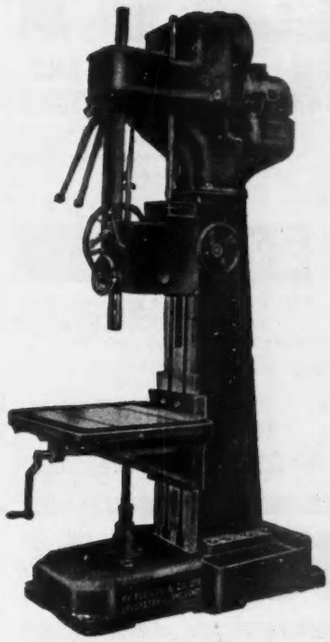

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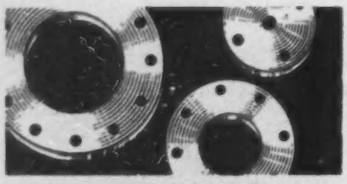

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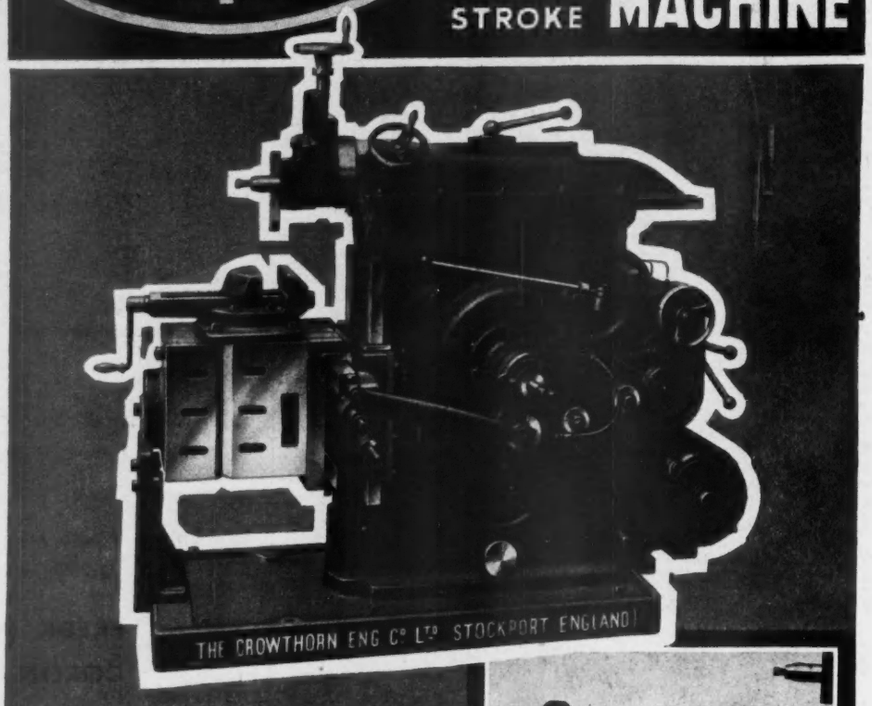

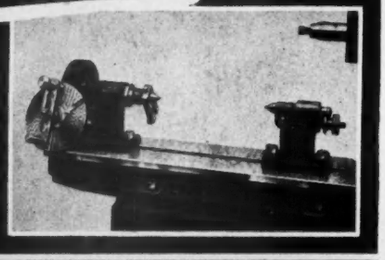

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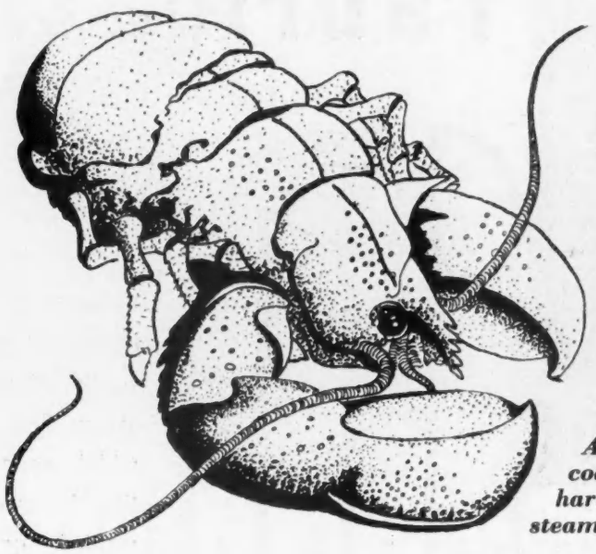

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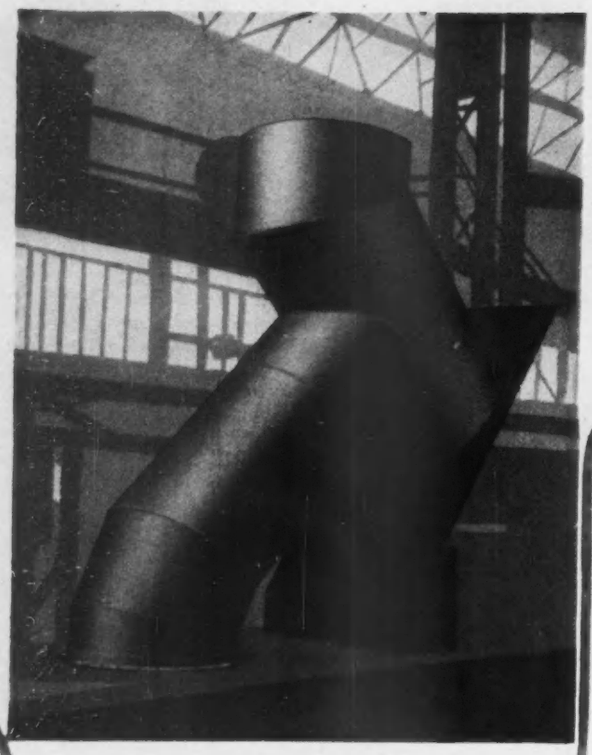

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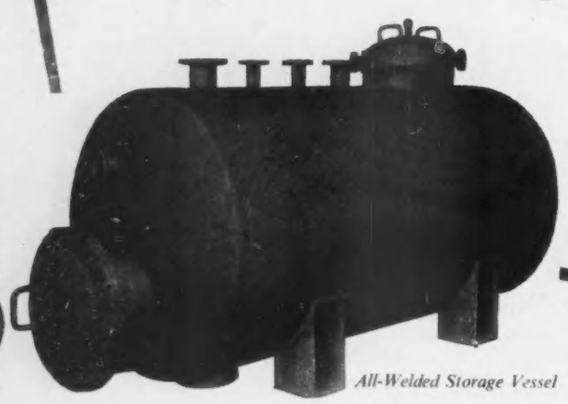

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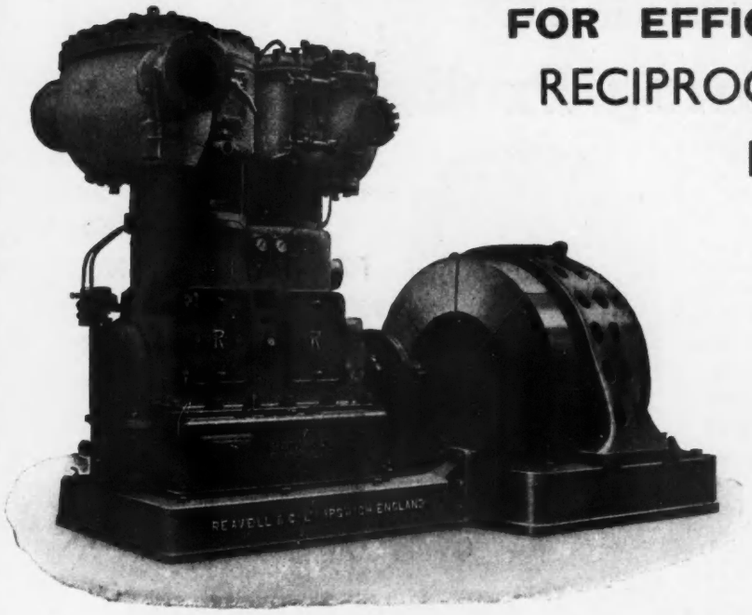

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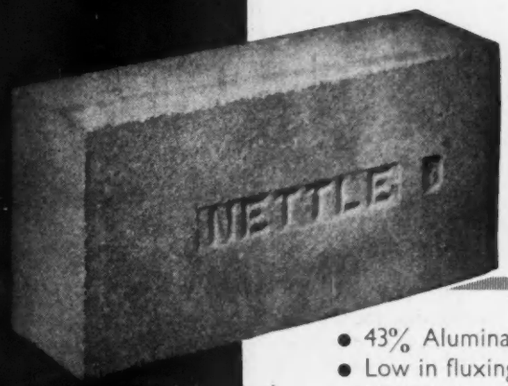

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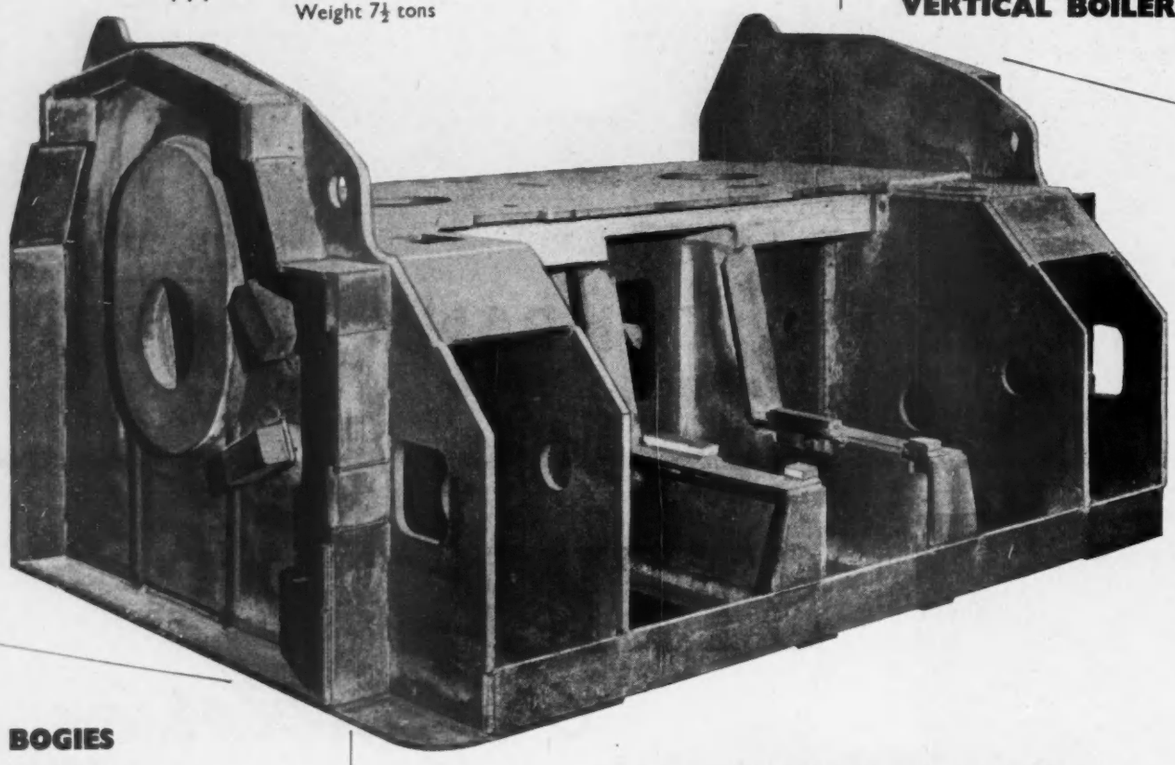

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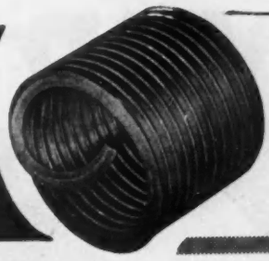

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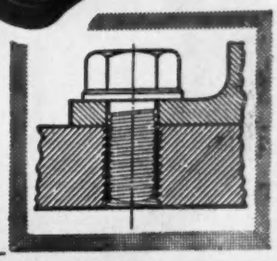

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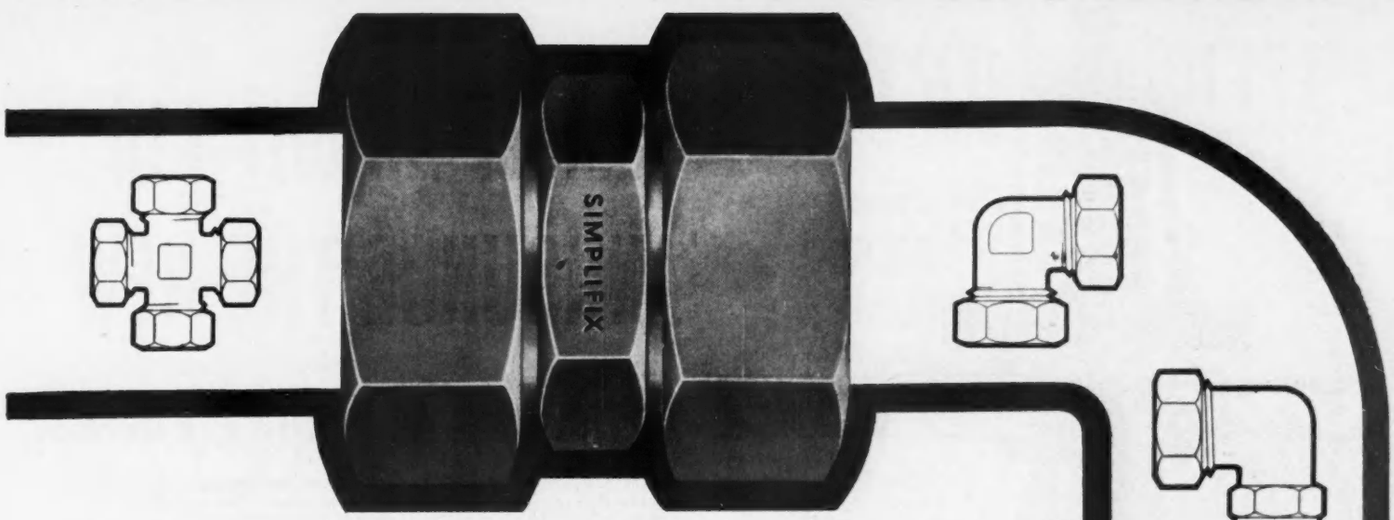

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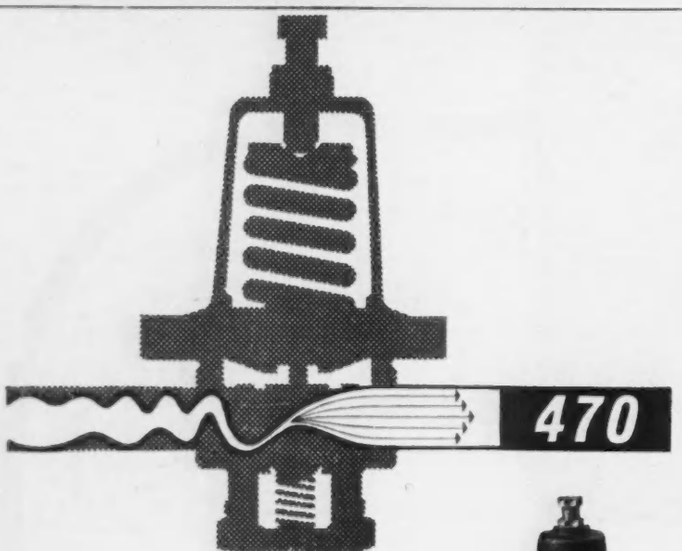

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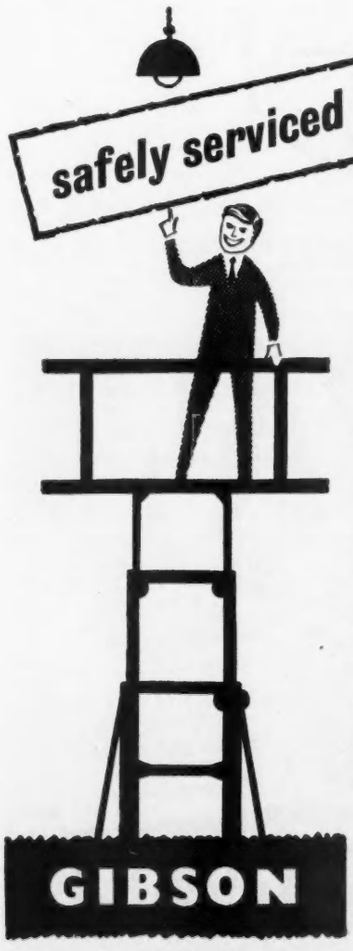

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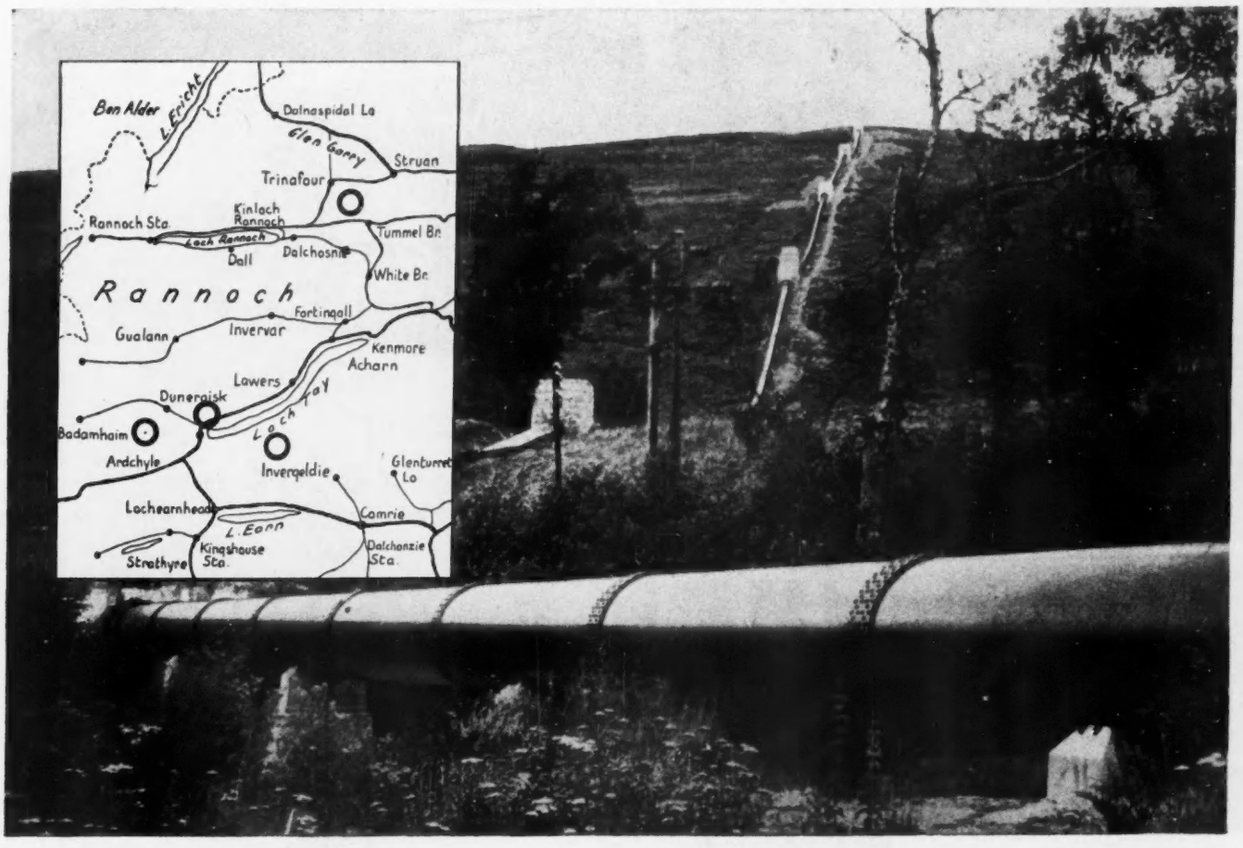

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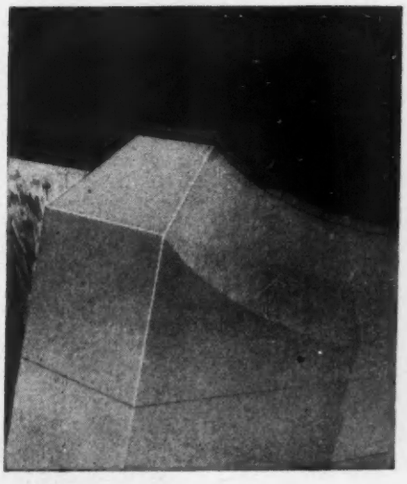

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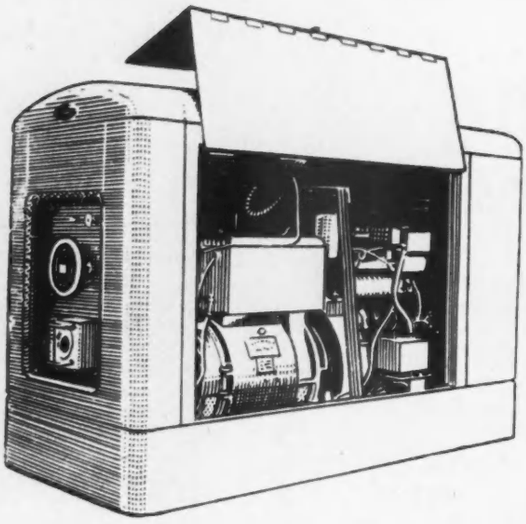

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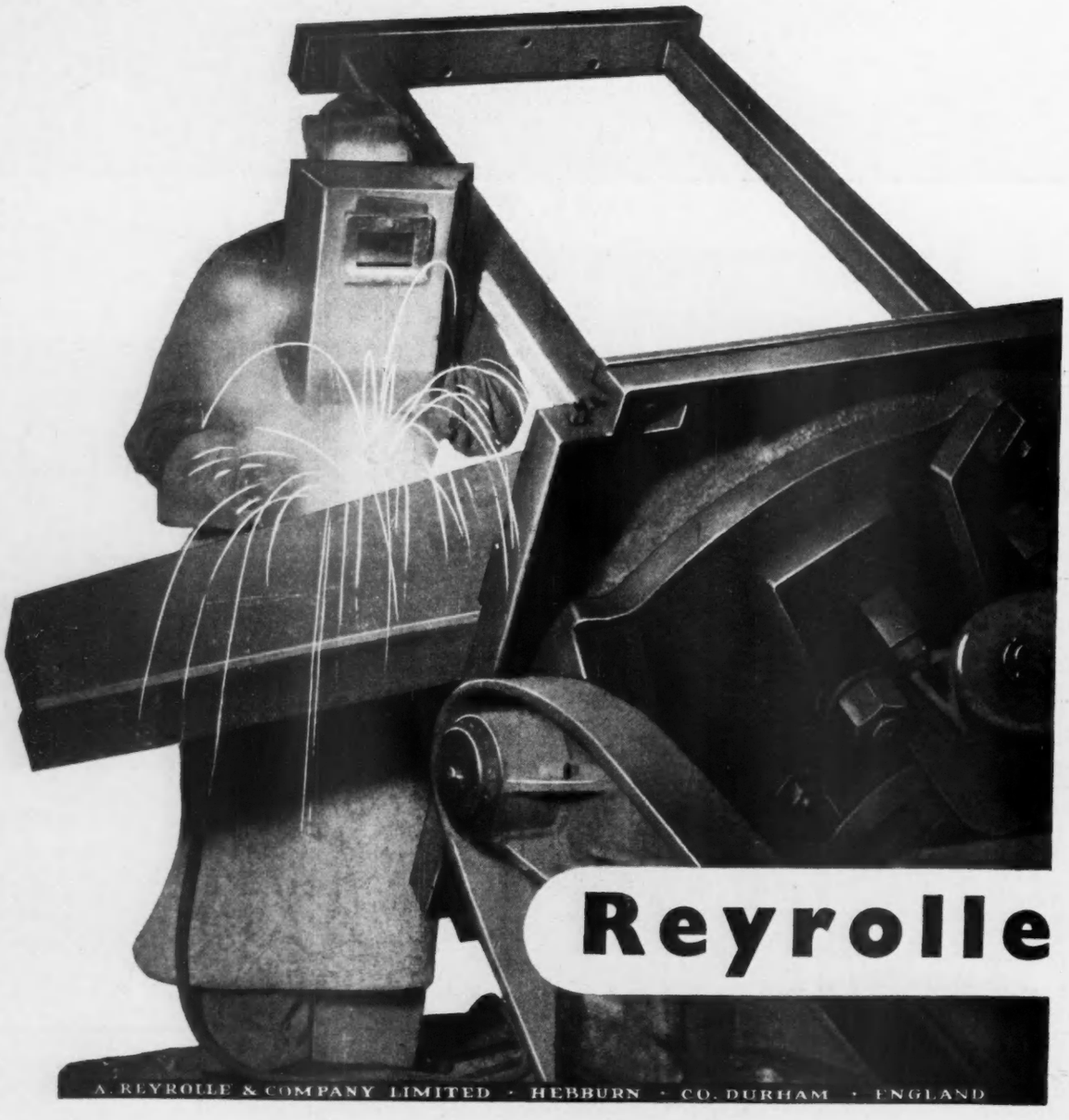

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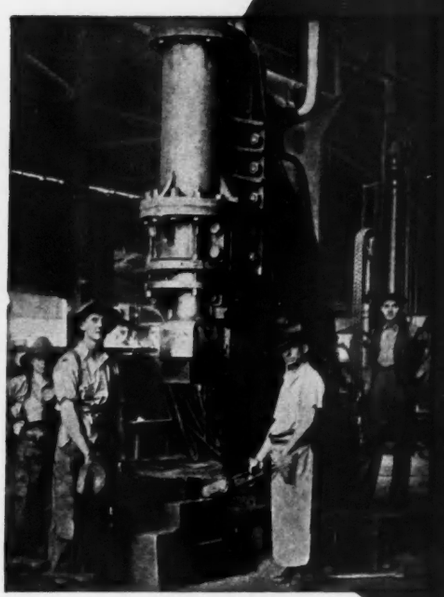

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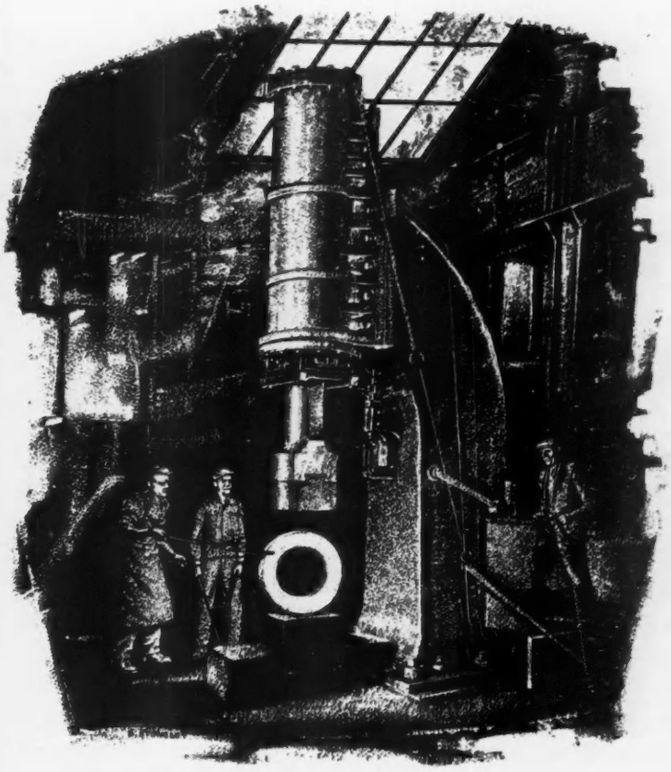

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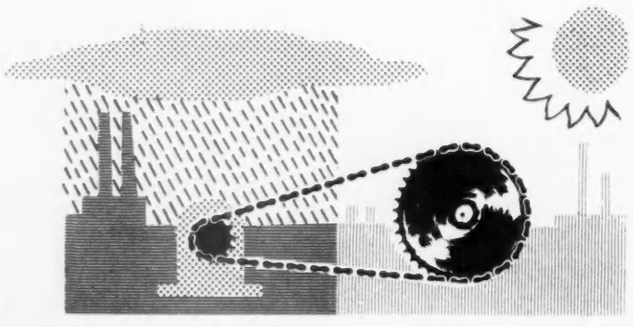

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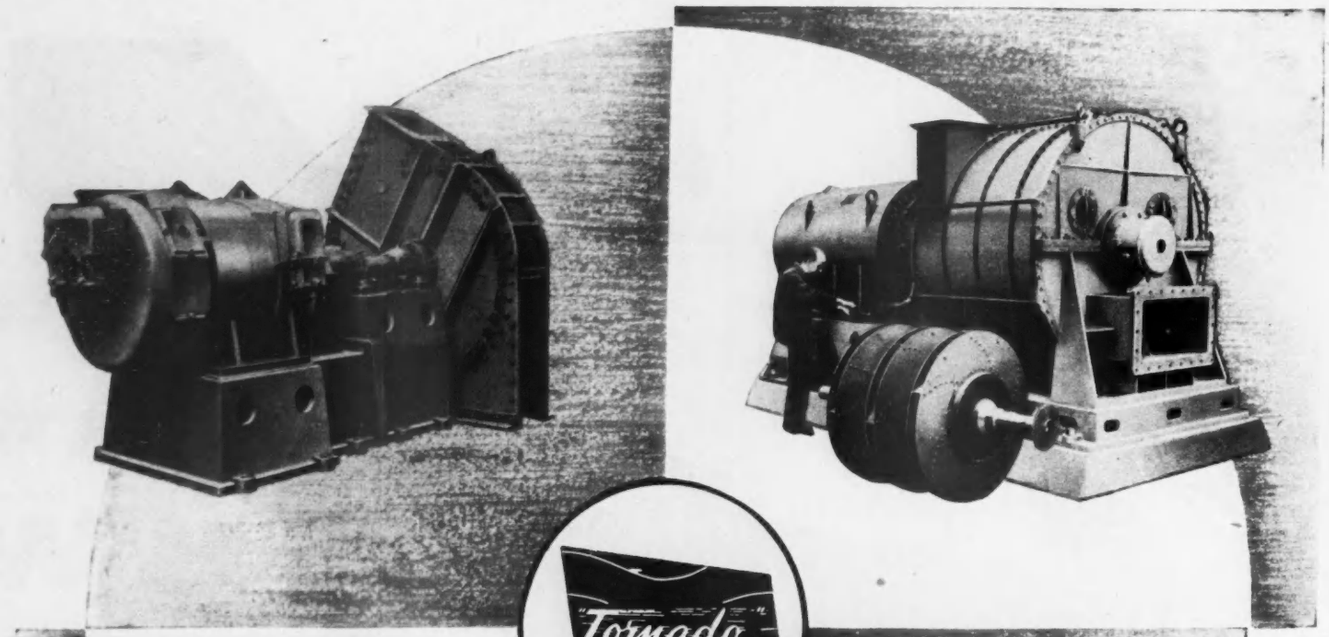

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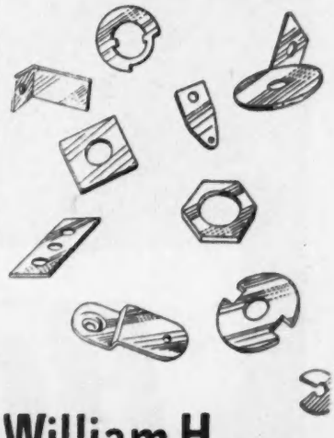

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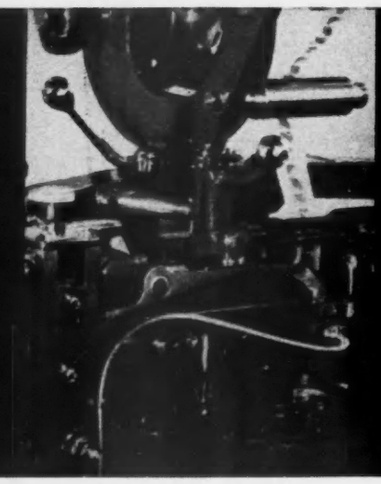

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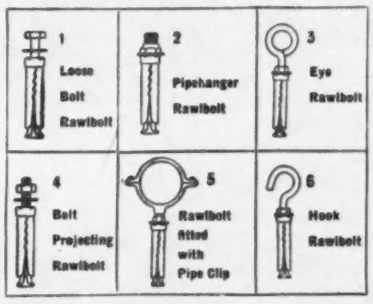

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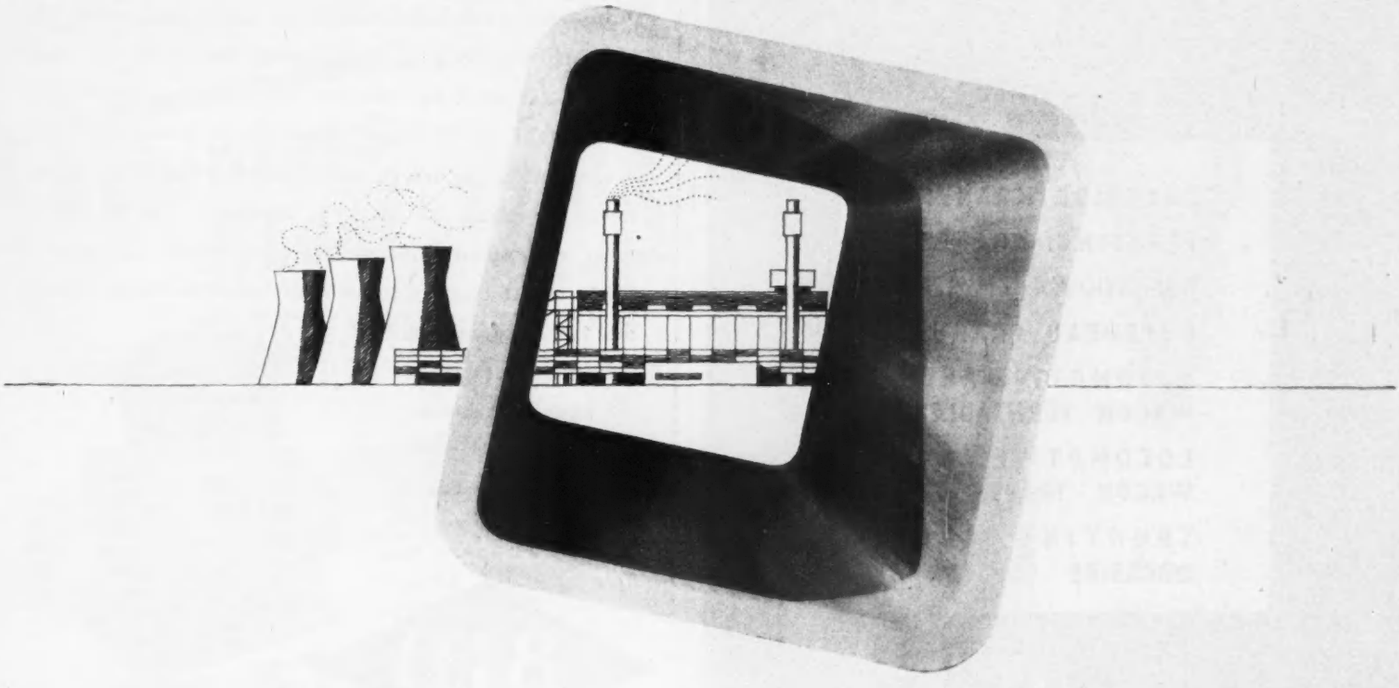

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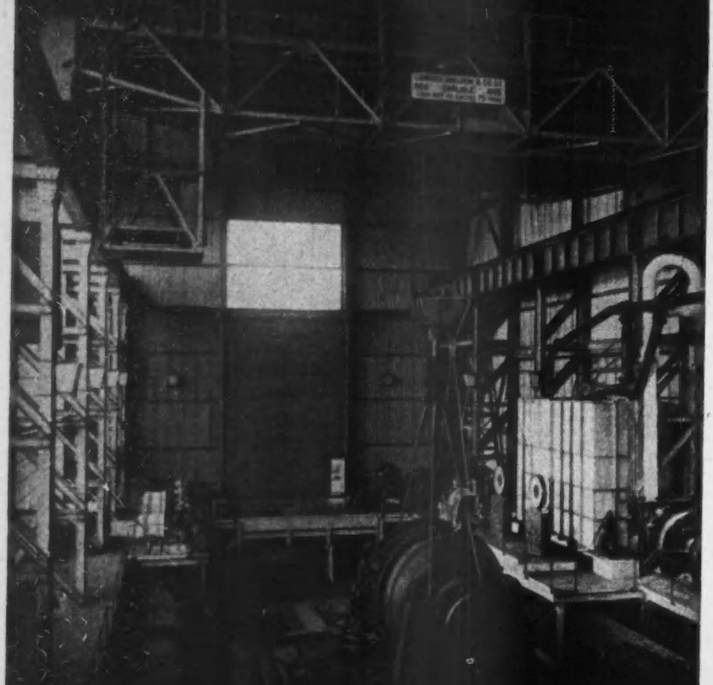

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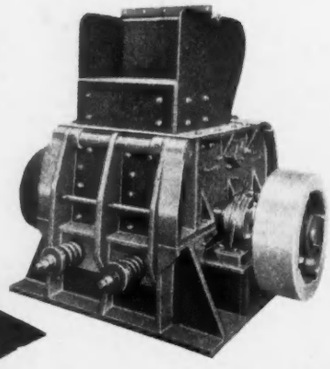
FLOATING CRANES
BREAKDOWN CRANES
OVERHEAD CRANES
LOCOMOTIVE AND WAGON TURNTABLES
LOCOMOTIVE AND WAGON TRAVERSERS
SHUNTING AND DOCKSIDE CAPSTANS

COWANS SHELDON & CO LTD

CARLISLE ENGLAND TELEPHONE CARLISLE 24196-7
LONDON OFFICE: AFRICA HOUSE KINGSWAY W.C.2 TELEPHONE HOLBORN 0268

making an impact

SWINGING a hatchet to chop domestic firewood is a laborious process, not without hazards when it comes to breaking the sticks into small lengths. Breaking *industrial materials* to small sizes is the job B.J-D Crushers do—easily and safely. For example, the B.J-D Swarf Breaker reduces voluminous swarf to small pieces that can be readily shovelled—of a size, in fact, to suit the furnace (or the scrap merchant). *All the leading motor manufacturers have installed these machines.* The range of B.J-D impact crushers covers most industrial needs: indeed, the top firms in many industries use them for all kinds of unusual applications. May we tell you more about B.J-D Crushers?



BJD

MINING MACHINERY EXHIBITION

18

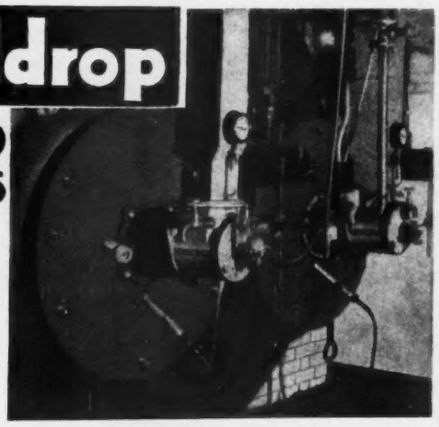
CRUSHERS

BRITISH JEFFREY-DIAMOND LIMITED,
CRUSHER & INDUSTRIAL DIVISION, 15-17 CAXTON STREET, LONDON S.W.1.

WF5101

Schieldrop

OIL FIRED BOILERS



We Guarantee

13½ to 14 per cent CO_2 with Shell Smoke number 4 or less.

Write for Catalogue quoting Reference A/11

Schieldrop & CO. LTD
STOTFOLD, BEDS. Tel. 414 (4 lines)

OFFICES AT: BIRMINGHAM · LONDON · MANCHESTER
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Forgings

GEORGE MILLS (ENGINEERS) LTD. Established 1920
214-218 RAVENSCROFT RD., BECKENHAM, KENT. Telephone: SYDenham 5255

IN IRON & STEEL UP TO 1½ CWTS.

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PROTOTYPES AND SPECIAL PURPOSE MACHINES

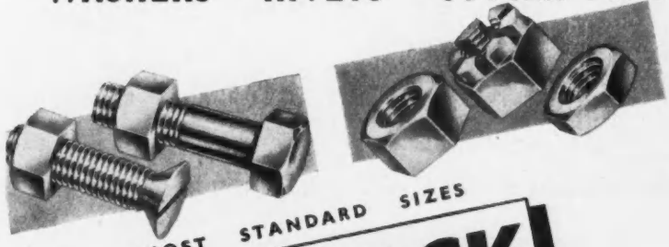
HEAVY AND "AWKWARD" MACHINING & GRINDING

REPAIRS & SALVAGE BY METAL DEPOSITION IN STELLITE, CHROME, NICKEL Etc.

WELDING FABRICATING PROFILE FLAME CUTTING AND GENERAL PRESSWORK

Stainless Steel 18/8

BOLTS · NUTS · SCREWS
WASHERS · RIVETS · COTTER PINS



MOST STANDARD SIZES

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Price list available on request.

FROM THE SPECIALISTS

G. F. BRIDGES LTD

SNOW HILL, BIRMINGHAM TEL: CENTRAL 3911—5 LINES

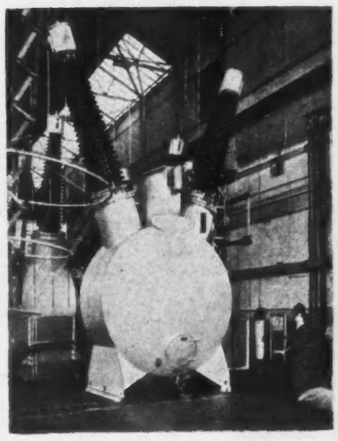
GFB

KARIBA at 330 kV.

All the bushing porcelains for the 330 kV. circuit breakers
All the 330 kV. strain insulators for the substations
and the 330 kV. post insulators for some of the substations by

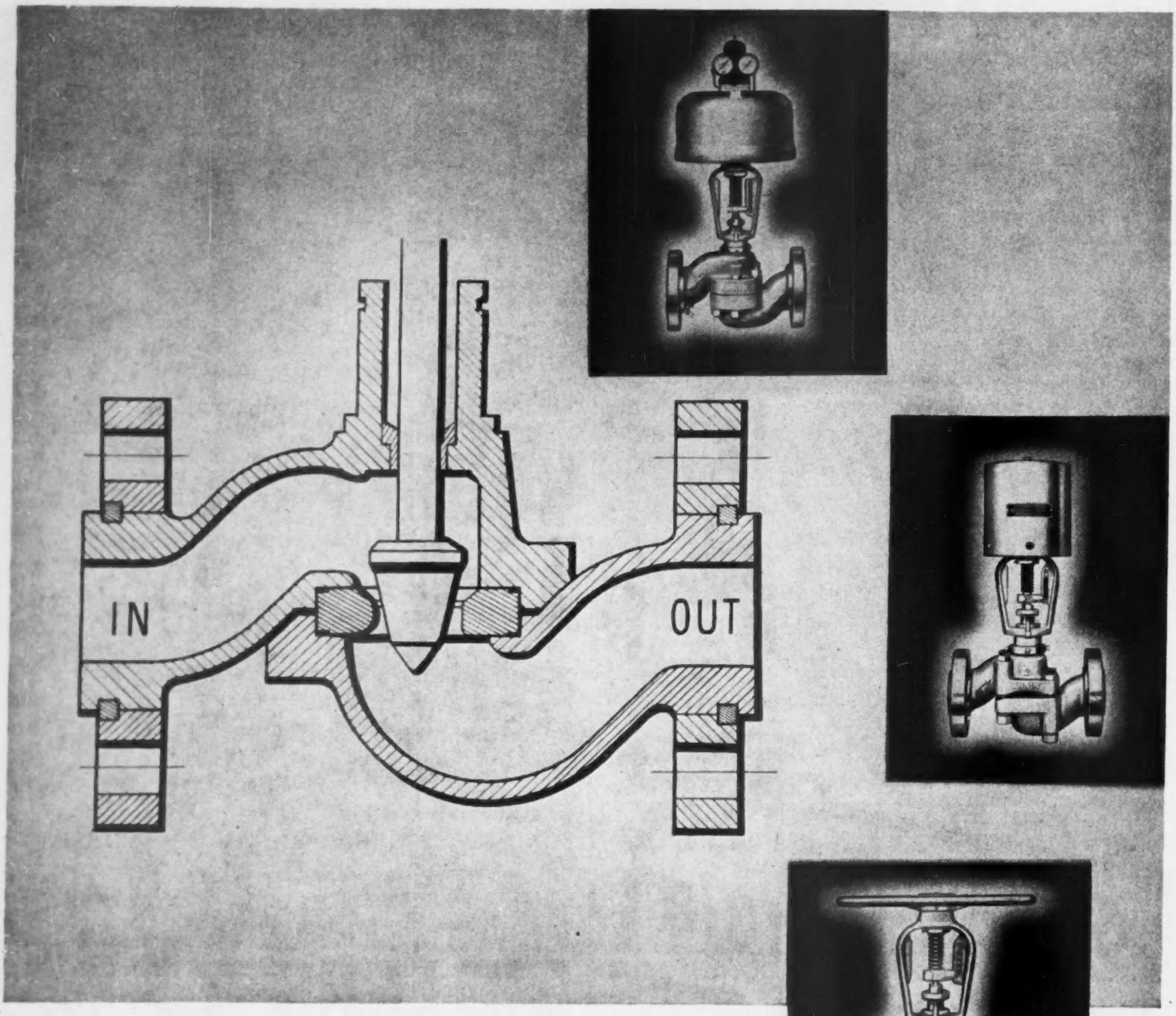
BULLERS

MAIN CONTRACTORS · B.T.H. Co. Ltd.
Consulting Engineers · Merz & McLellan



The illustrations show a complete 330 kV. bushing insulator and a 330 kV. circuit breaker, by courtesy of the B.T.H. Co.

BULLERS LIMITED · MILTON · STOKE-ON-TRENT · STAFFS
Telephone: Stoke-on-Trent 54321
London: 6 Laurence Pountney Hill, E.C.4. Tel.: MANsion House 9971



The Answer to Fluid Control Problems

Audco Annin Valves are recognised by Control Engineers and Valve Designers as the outstanding valve development of the past 25 years for the control of hot, cold, erosive, corrosive or viscous liquids.

The Split Body construction offers the following advantages:—

- The Easy "S" flow line eliminates pockets and shoulders, and reduces erosion.
- The advantages of single seated valves plus Cv values comparable with equivalent size double beat valves.
- Speedy inspection or removal of seat ring and integral stem and plug without removal of the valve from the line.
- Adaptable to form angle type bodies.
- Available in a wide range of materials with separable or integral flanges, with screwed or butt weld end connections, depending on size and rating.
- Also supplied in threeway form with the same outstanding features.

AUDCO ANNIN Valves

COMPLETE RANGE OF VALVES UP TO 2500 ASA RATING

AUDLEY ENGINEERING COMPANY LIMITED, NEWPORT, SHROPSHIRE

UNIT

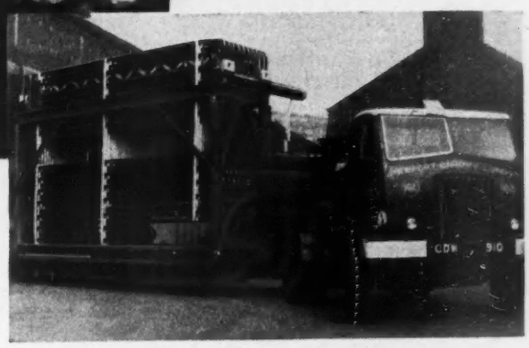
SEAMLESS STEEL TUBULAR COILS

The steel header above forms part of a large tubular coil illustrated on the right. This is a typical example of the construction undertaken at our Unit Works.

The coil, supplied to National Coal Board power station in South Wales, comprises 20 outer element grids and 18 inner element grids formed from cold-drawn seamless steel tubes 2¼ in. o.d., 6 g. and 7 g. thick.

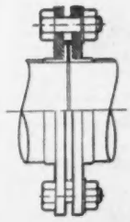
We specialize in the supply of tubular steel products of all descriptions for power stations and industrial steam raising plants, including pipework for high or low pressures, steam and oil receivers, water wall headers and de-superheater bodies.

A complete non-destructive testing service is also undertaken by our own staff.



THE UNIT SUPERHEATER AND PIPE CO. LTD · UNIT WORKS SWANSEA. Telephone: Swansea 54091 (6 lines) Telegrams: 'Superunits', Swansea. Telex 48-208.

STANDARD UNIT LIGHT-WALL STAINLESS STEEL PIPING



Here's an entirely new conception of piping —a comprehensive range of standard units, in four bore sizes (3", 4", 6" and 8") plus reducers that can be assembled, dismantled and re-assembled time and time again by comparatively unskilled labour. Swept bends and a unique system of gasket jointing eliminate all bacteria harbouring crevices and ensure an uninterrupted flow, free from blockages of any kind. Standard straights, bends, tees and reducers permit a wide variety of applications while further units can always be purchased for expansion or variation.

LET

WELTEXA

SHAPE YOUR FUTURE

Interested ? Then send for our technical booklet "The WELTEXA System," today.

WELDING TECHNICAL SERVICES LTD. (DEPT. D), HURST MILL, KINGS NORTON, BIRMINGHAM 30

CLASSIFIED ADVERTISEMENTS

AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-.

Inch Rate. 48/- per single column inch and *pro rata*. 12 lines to 1 inch. There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g. ¼-page £25 10s. ½-page £48. Full page £90.

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

Lineage Rate. 3/6 per line of approximately 6 words. Minimum 14/-.

Inch Rate. 42/- per single column inch and *pro rata*. 12 lines to 1 inch. There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page. (12 column inches) and upwards, e.g. ¼-page £22. ½-page £41 10s. Full page £78.

Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

***Advertisements for publication should be addressed to:*—Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565

PUBLIC APPOINTMENTS

EDUCATION DEPARTMENT OF WESTERN AUSTRALIA

TECHNICAL EDUCATION DIVISION

PERTH TECHNICAL COLLEGE

Applications are invited for the following positions:
LECTURER IN STRUCTURAL ENGINEERING WITH GROUP IV ALLOWANCES.

Applicants must be qualified for Corporate Membership of the Institution of Engineers (Australia) or equivalent institution. They should have had experience in the structural field. The following will be an advantage :—

(i) Higher qualifications in engineering.
(ii) Special qualifications and/or experience in hydraulics.
(iii) Experience in the field of civil engineering.
(iv) Teaching experience.

Salary range : £A1500–£A1985.

LECTURER IN COMMUNICATIONS ENGINEERING WITH GROUP III ALLOWANCES.

Applicants must be qualified for Corporate Membership of the Institution of Engineers (Australia) or equivalent institution, and must have special qualifications and/or experience in the communications field.

Salary range : £A1300–£A1820.

In either position permission may be granted for a limited amount of consultative practice.

Applications must be made on the prescribed form, T.E.1, which can be obtained from the Agent General for W.A., Savoy House, 116–118, Strand, London, W.C.2, from whom further particulars, including those of travel arrangements, are also available. All applications must reach the Agent General in duplicate and accompanied by a recent photograph on or before the 30th June, 1959.

E5943

UNIVERSITY OF DURHAM

KING'S COLLEGE, NEWCASTLE UPON TYNE, 1

DEPARTMENT OF CIVIL ENGINEERING

RESEARCH ASSISTANT IN PUBLIC HEALTH ENGINEERING

The Council of King's College invite applications for a RESEARCH ASSISTANTSHIP IN PUBLIC HEALTH ENGINEERING in the Department of Civil Engineering.

Candidates should be graduates of a British University in Civil Engineering. The appointment, which will be for one year in the first instance, may be renewed annually up to a total of three years. The commencing salary will be determined at an appropriate point within the range £500–£700 per annum according to qualifications and experience.

Further particulars may be obtained from the Registrar of King's College to whom applications, together with the names and addresses of three referees, should be addressed so as to reach him not later than 30th June, 1959. E5906

UNIVERSITY OF HONG KONG

READERSHIP IN MECHANICAL ENGINEERING

Applications are invited for the above post. Applicants must be Graduates of a British Commonwealth University or equivalent and must be Corporate Members of the Institution of Mechanical Engineers, with teaching experience at University level. Preference will be given to those with special qualifications in Engineering Thermodynamics.

Annual salary (superannuable) is £2500 (man) or £1900 (woman), together with an expatriation allowance of £300 a year if applicable. The equivalent of income tax in the Colony is comparatively low.

First-class sea passages are provided for expatriate staff and their families on first appointment and leaves.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1.

Applications close, in Hong Kong and London, on 30th June, 1959. E5927

PUBLIC APPOINTMENTS

UNIVERSITY OF HONG KONG

LECTURESHIPS IN ENGINEERING

Applications are invited for the above newly-established posts. Applicants must be Graduates of a British Commonwealth University or equivalent and should preferably be Corporate Members of the Institution of Mechanical Engineers or the Institution of Electrical Engineers. Preference will be given to those candidates with teaching experience at university level and specialised experience in Fluid Mechanics, Theory and Design of Machines or Electronic Engineering.

Annual salary (superannuable) is £1575 by £50 to £2175 (man) or £1200 by £40 to £1680 (woman), together with an expatriation allowance of £225 a year if applicable. The equivalent of income tax in the Colony is comparatively low.

First-class sea passages are provided for expatriate staff and their families on first appointment and leaves.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1.

Applications close, in Hong Kong and London, on 30th June, 1959. E5928

MIDDLESEX COUNTY COUNCIL

EDUCATION COMMITTEE

ACTON TECHNICAL COLLEGE, HIGH STREET, ACTON, W.3

LECTURER

Required for 1st September, 1959 :

LECTURER, to teach Electrical Engineering subjects to the level of Ordinary National Diploma and Ordinary National Certificate in Electrical Engineering and City and Guilds Telecommunications Technicians' Certificate. The candidate appointed will be responsible for the organisation of this work throughout the College courses in Engineering. Graduate or equivalent qualifications required, with good teaching and industrial experience.

Burnham Technical Salary Scales within the range (for men) £1297 16s. to £1467 18s. per annum.

Application forms and further details (foolscap s.a.e.) from the Principal. Closing date 12th June.

C. E. GURR, M.Sc., Ph.D.,
Secretary to the Education Committee.

E5934

QUEEN MARY COLLEGE
(UNIVERSITY OF LONDON)

LECTURER IN MECHANICAL ENGINEERING

Applications are invited for the post of LECTURER IN MECHANICAL ENGINEERING. Salary scale £900 by £50 to £1350 (efficiency bar) : £1425 by £75 to £1650 plus London Allowance £60 (initial salary according to qualifications and experience) with F.S.S.U. participation and family allowance of £50 for each child. Application forms to be returned to the Registrar, Queen Mary College, Mile End Road, E.1, by June 13th. E5909

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

H.Q. INFORMATION DIVISION, LONDON

SENIOR SCIENTIFIC OFFICER

D.S.I.R. requires SENIOR SCIENTIFIC OFFICER in H.Q. Information Division, London, to keep abreast of scientific and technical developments, particularly in engineering field, assist with enquiries and undertake such special studies as necessary. Qualifications : 1st or 2nd Honours degree in mechanical or chemical engineering or equivalent at least three years' appropriate post-graduate experience. Candidates should have wide interest in application of science rather than in academic research. Appreciation of scientific aspects of industrial problems and an aptitude for dealing with people. Salary (men) £1233 to £1460. Starting salary may be above minimum. Prospects of promotion to Principal S.O. (£1500 to £2120) in mid-thirties and, whilst under 31, of establishment through Civil Service Commission. Five-day week. Forms from M.L.N.S. Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting reference C372/9A. Closing date 26th June, 1959. E5932

PUBLIC APPOINTMENTS

BOROUGH OF FARNWORTH

MAIN OUTFALL SEWER

CONTRACT NO. 5

APPOINTMENT OF RESIDENT ENGINEER

Applications are invited from suitably qualified engineers for the temporary appointment of RESIDENT ENGINEER to supervise the construction of a 78in. diameter brick-lined sewer in tunnel, 57in. diameter to 78in. diameter concrete pipes laid in open trench, various manholes and ancillary works.

Applicants should have had experience of tunnelling using pre-cast concrete segments and of open trench work in waterlogged ground. The work will be carried out under the direction of Messrs. J. D. and D. M. Watson, MM.I.C.E., Consulting Engineers to the Borough of Farnworth and the probable duration will be 18 months. The salary will be in the range of £1250 to £1500 per annum and will depend on qualifications and experience.

Applications, stating age, qualifications and experience, together with the names and addresses of two referees, must reach the undersigned not later than 15th June, 1959.

THOMAS HITCHEN,
Town Clerk.

Town Hall,
Farnworth, Lancs. E5933

COMMISSIONERS OF IRISH LIGHTS

VACANCY FOR JUNIOR ASSISTANT WORKSHOPS MANAGER

Applications are invited for the permanent and pensionable post of JUNIOR ASSISTANT WORKSHOPS MANAGER at the Lighthouse Depot, Dun Laoghaire, County Dublin.

Applicants, who should be between the ages of 25 and 35, must have been trained in a mechanical engineering works of repute and have passed Parts A and B of the examination of the Institution of Mechanical Engineers, or hold equivalent qualifications.

The basic salary is £650 by £25 to £900 per annum. This is subject to a cost-of-living bonus which, at the present rates, brings the salary scale up to £860–£1166 per annum.

Further particulars of the appointment and conditions of service may be obtained from the undersigned.

Applications, giving full particulars of age, education, training, experience and qualifications, should reach this office not later than Monday, 8th June, 1959, addressed to "The Secretary."

V. ALLMAN-SMITH,
Secretary.

Irish Lights Office,
28, D'Olier Street,
Dublin. E5937

DUNMOW RURAL DISTRICT COUNCIL

APPOINTMENT OF ASSISTANT RESIDENT ENGINEER

Applications are invited for the above appointment on the staff of the Resident Engineer for the construction of sewerage and sewage disposal works under the direction of the Consulting Engineers, J. D. and D. M. Watson, MM.I.C.E., 67, Tufton Street, Westminster, S.W.1. Applicants should be suitably qualified and preferably have some knowledge of sewerage and sewage disposal design.

The salary offered will be £850 per annum according to qualifications and experience. The appointment will be subject to one month's notice on either side and, subject to satisfactory service, is expected to last at least a year. Some travelling is likely to be necessary and if the person appointed uses his own car on duty the Council will pay a travelling allowance at a rate not exceeding that payable for a 10 h.p. or 1199 c.c. vehicle in accordance with the National Scheme of Conditions of Service.

Applicants should apply by 20th June, 1959, in writing, to the undersigned, giving full particulars of age, qualifications and experience, and enclose copies of not less than two testimonials or the names of two referees.

A. H. BURTON,
Clerk of the Council.

Council Offices,
Dunmow, Essex. E5955

PUBLIC APPOINTMENTS

ROYAL NAVAL SCIENTIFIC SERVICE

SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS

Vacancies for SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS in following localities:

LONDON AREA : MECHANICAL ENGINEER with sound knowledge of basic principles of thermo and fluid dynamics, to carry out research programme in a particular field of applied hydrodynamics. Experience in modern methods of design and research on axial flow compressors, turbines or pumps an advantage. MECHANICAL ENGINEER for work on propulsion problems. APPLIED MATHEMATICIAN for research of basic nature on stability of underwater vehicles : knowledge of theoretical hydrodynamics and theory of control systems an advantage. APPLIED MATHEMATICIAN or THEORETICAL PHYSICISTS for acoustic analysis. ELECTRONIC PHYSICISTS for data handling and analysis problems. PHYSICIST interested in operator performance. CLASSICAL PHYSICISTS.

BALDOCK : PHYSICISTS or APPLIED MATHEMATICIANS for research in Metal or Quantum Physics.

PORTSMOUTH : ELECTRONIC ENGINEERS for research on analogue computers and transistor circuits. ELECTRICAL ENGINEERS for research on small rotating electrical machinery. PHYSICISTS—for optical systems and instrumentation. ELECTRO-MECHANICAL ENGINEERS — for work on servo-mechanisms.

PORTLAND : PHYSICISTS or APPLIED MATHEMATICIANS for research on underwater acoustics. ELECTRONIC PHYSICISTS, ELECTRONIC ENGINEERS—for design work. PHYSICAL CHEMISTS.

POOLE : CHEMICAL ENGINEERS. CHEMISTS for work on rubber technology.

ROSYTH : PHYSICISTS (Electronic).

Candidates must normally be natural born British subjects of natural born British parents, with First or Second-Class Hons. Degrees. S.S.O.s must have had three years' post-graduate experience and be not less than 26 years of age. Salaries : (men) S.S.O., £1233–£1460 ; S.O., £655–£1150 (London), somewhat lower in provinces. Appointments unestablished (with F.S.S.U. benefits), but opportunities may occur for those between ages of 21 and 32 to compete for established posts.

Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1 (quote A.220/9A). E5866

KING'S LYNN AREA HOSPITALS MANAGEMENT COMMITTEE

SUPERINTENDENT ENGINEER

SUPERINTENDENT ENGINEER required, who will be responsible for the satisfactory operation, maintenance and co-ordination of the Engineering Services and activities, both mechanical and electrical, of the Group of Hospitals ; supervision of engineering maintenance works and the keeping of all necessary records, &c. Applicants should be qualified in accordance with Ministry of Health requirements. Salary : £825 by £25 (3) by £30 (2) to £960.

Applications, stating age and giving details of qualifications and experience, together with names and addresses of two referees, to be received by the Group Secretary, St. James's Hospital, Extons Road, King's Lynn, not later than 23rd May, 1959. E5671

SOUTH-EAST METROPOLITAN REGIONAL HOSPITAL BOARD

DEPUTY REGIONAL ENGINEER

South-East Metropolitan Regional Hospital Board invites applications for the post of DEPUTY REGIONAL ENGINEER (salary £1465 by £55 (4) by £35 (1) to £1720, inclusive of London Weighting allowance. Superannuable. The successful candidate will be required to act for the Regional Engineer over the whole range of the services for which the Engineer is responsible, viz., mechanical and electrical engineering, and must have extensive professional and technical experience and full professional qualifications and status.

Further details are obtainable from the Regional Engineer at 40, Eastbourne Terrace, W.2.

Applications, stating qualifications and experience, with names of three referees, should reach the Secretary, 40, Eastbourne Terrace, W.2, by 9th June. E5911

PUBLIC APPOINTMENTS

BRITISH TRANSPORT COMMISSION

APPOINTMENTS

British Transport Commission requires, in the Department of the Chief Electrical Engineer at 14, Melbury Terrace, Marylebone, London, N.W.1 :

POST (1) PRINCIPAL SCIENTIFIC OFFICER—salary range £1535–£1815.

Engineer or Physicist with good Degree and considerable experience in the organisation and execution of research projects. Interest in one or more of the following : physics of the solid state, properties of metal surfaces, electrical contact phenomena or friction and wear. Initially will be required to work on problem of controlling adhesion between wheel and rail ; later opportunities for original work within the broad field embraced by electric traction.

SENIOR SCIENTIFIC OFFICERS—salary according to qualifications and experience, subject to a maximum of £1315.

Good Degree and post-graduate research experience. Industrial training an advantage. Initially may be required to spend two to three years on research in Universities or industrial firms.

POST (2) Interest in surface phenomena in electrical engineering and will be required initially to co-operate in an investigation of commutation and current collection.

POST (3) Application of modern techniques such as semi-conductors or magnetic amplifiers to electric traction problems. Thorough grounding in electro-magnetic theory required.

POST (4) Thermal problems associated with electric equipment. Good knowledge of theory of heat transfer and expertise in all forms of temperature measurement essential.

TECHNICAL ASSISTANTS—salary range £833–£903.

POST (5) Engineer or Physicist, preferably possessing Degree or equivalent qualification, with some experience in application of modern instrumentation with special emphasis on electronic methods.

POSTS (6) and (7) Engineers qualified for A.M.I.E.E. or A.M.I.M.E., and having experience of conduct of experiments.

POST (8) TECHNICAL ASSISTANT—salary range £943–£985.

Engineer with Degree or equivalent qualification, experienced in application of modern instrumentation, with special emphasis on electronic methods.

Superannuation scheme. Certain free travel facilities. Medical examination.

Write, quoting post number and stating age, qualifications and experience, to Director of Establishment, British Transport Commission, 222, Marylebone Road, London, N.W.1, within 14 days. S.A.E. for acknowledgment. E5916

PUBLIC APPOINTMENTS

FEDERAL GOVERNMENT OF NIGERIA

ELECTRICAL INSPECTOR

Under the Chief Inspector, to inspect electrical supply undertakings and large consumers' installations, including factories, mines and oil wells, and to investigate and conduct enquiries into electrical accidents.

Contract appointment. Salary range £1290–£1674. Gratuity of £37 10s. for each three months' satisfactory service. Quarters at moderate rent. Free passages. Allowance for children maintained in United Kingdom. Generous home leave.

Candidates must be A.M.I.E.E. or be exempt the Institution's examination and have been apprenticed to an electrical supply undertaking or large industrial undertaking with at least 7 years' experience of responsibility involving the planning, erection and maintenance of electrical transmission and distribution systems or works electrical plants. A thorough knowledge of electrical supply and wiring regulations as they apply in the United Kingdom is essential.

Write, Director of Recruitment, Colonial Office, London, S.W.1, stating age, qualifications and experience, quoting BCD 99/14/014. E5919

LIVERPOOL REGIONAL HOSPITAL BOARD

SENIOR ASSISTANT ENGINEER (MECHANICAL)

SENIOR ASSISTANT ENGINEER (MECHANICAL) required on the staff of the Regional Engineer's Division of the Board's Headquarters.

Applicants should be Corporate Members of the Institution of Mechanical Engineers, with a wide experience in the design and operation of all kinds of heating, hot water and ventilating systems as applied to hospitals or other similar type of buildings. Experience in the preparation of drawings, specifications, estimating and supervision of contracts also necessary.

Commencing salary : £1050 by £30 (3) by £35 (3) to £1245 per annum.

Applications, stating age, qualifications, experience, present and previous posts, together with names and addresses of three referees (two technical), to reach me at 55, Castle Street, Liverpool, 2, by 29th June, 1959.

VINCENT COLLINGE,
Secretary to the Board.

E5923

PUBLIC APPOINTMENTS

MINISTRY OF SUPPLY

SOUTH MARSTON, SWINDON, WILTS

TECHNICIAN

Ministry of Supply require a TECHNICIAN at South Marston, Swindon, Wilts, to assist at the works of a Contractor, in the supervision of the inspection of prototype and production aircraft, including electrical, radio and instrument installations. Qualifications : Recognised engineering apprenticeship or equivalent training in appropriate trade. O.N.C., appropriate C. and G. Final Certificates or equivalent qualification desirable. Sound knowledge of aircraft and light electrical engineering and preferably also of electronics as applied to aircraft installations. Rate of Pay : £850 (age 30) to £1005 p.a. Application Forms from Ministry of Labour and National Service, Professional and Executive Register (P.E.868), Atlantic House, Farringdon Street, London, E.C.4. E5956

MINISTRY OF SUPPLY

STEVENAGE, HERTS

TECHNICIAN

Ministry of Supply require a TECHNICIAN at Stevenage, Herts, to assist with supervisory inspection and testing duties at the works of a contractor engaged on the manufacture of guided weapons. Qualifications : Recognised apprenticeship in electrical engineering or equivalent training in an appropriate trade. Previous practical experience either in design, testing, inspection, manufacture or installation of light electrical equipment and instruments. Some knowledge of electronics advantageous. Possession of O.N.C. (Electrical), appropriate C. & G. Final Certificates or equivalent qualification desirable. Rate of Pay : £850 (age 30) to £1005 p.a. (Provincial). Application Forms from Ministry of Labour and National Service, Professional and Executive Register, Atlantic House, Farringdon Street, London, E.C.4, quoting PE.1140. E5931

NEW CROSS GENERAL HOSPITAL

SENIOR ENGINEER

Applications are invited for the post of SENIOR ENGINEER, under the direction of the Superintendent Engineer. Salary in accordance with the Whitley Council Professional and Technical Council "B," viz.: £680 by £25 (3) by £30 (2) to £815, plus London Weighting. Candidates must have served a recognised engineering apprenticeship and hold one of the following qualifications : First Class Certificate in Marine Engineering, City and Guilds Full Technological Certificate in Plant Engineering (First Class).

Apply, stating age, education, professional training, qualifications and experience, accompanied by copies of three testimonials, to be addressed to :

The Group Secretary,
New Cross General Hospital,
Avonley Road,
New Cross, S.E.14,

by the 6th June, 1959. E5913

MINISTRY OF SUPPLY

CHESSINGTON, SURREY

TECHNICIAN

Ministry of Supply require TECHNICIAN at Chessington, Surrey, to prepare technical publications on guided weapons.

Qualifications : Recognised engineering apprenticeship or equivalent training in appropriate trade. Higher National Certificate or equivalent qualifications desirable. Experience on small mechanical and electro-mechanical mechanisms or servo-mechanisms or light electrical equipment essential. Experience of writing or editing technical publications an advantage. Rate of pay : £1065–£1300 per annum.

Forms from M.L. and N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting C.367/9A. Closing date 19th June, 1959. E5918

CITY OF BIRMINGHAM WATER DEPARTMENT

APPOINTMENT OF TECHNICAL ASSISTANT

Applications invited for appointment of Technical Assistant at Frankley Waterworks, Birmingham. Candidates should have served an apprenticeship in mechanical and/or electrical engineering and be competent draughtsmen, with Higher National Certificate or equivalent. The successful applicant will be required to assist the Mechanical Engineer in the operation and maintenance of pumping machinery and in the design and installation of new pumping plant. Salary range £595–£1030 per annum, dependent upon qualifications and experience. Appointment permanent and pensionable—medical examination. Canvassing disqualifies. Application forms from General Manager, Water Department, Council House, Birmingham, 3, returnable by 15th June, 1959.

E5936

TENDERS

BOROUGH OF KING'S LYNN

GAYWOOD OUTFALL PUMPING STATION

TENDERS are invited for the SUPPLY and ERECTION at the above Pumping Station of Three Sets of Electrically Driven Vertical Centrifugal Pumps with ancillary equipment.

Copies of the Specification, Form of Tender and Drawing may be obtained from the office of Mr. H. G. Ridler, M.I.Mun.E., Borough Engineer, 17, Queen Street, King's Lynn, upon payment of a deposit of £2 2s. which will be refunded on receipt of a bona fide tender.

Tenders must be returned to the undersigned, in the envelope provided not later than noon on Wednesday, 1st July, 1959.

The Corporation does not bind itself to accept the lowest or any tender.

E. W. GOCHER,
Town Clerk.

Town Hall,
King's Lynn. E5899

COUNTY BOROUGH OF BRIGHTON

WATERWORKS DEPARTMENT

MILE OAK PUMPING STATION

AUTOMATIC PUMPING CONTROL EQUIPMENT

FIXED PRICE TENDERS invited for MANUFACTURE, DELIVERY, ERECTION, TESTING AND SETTING IN OPERATION equipment for remote and/or local automatic control of electrically driven submersible well pumps and booster pumps.

Specification and Particulars from Chief Engineer Water Department, 12, Bond Street, Brighton, 1, on payment of Two Guineas deposit to be refunded on receipt of a bona-fide tender and return of all documents.

Tenders in the plain sealed envelope provided not bearing any name or mark indicating the sender, endorsed "Tender for Remote/Automatic Control, Mile Oak," to be delivered to me by noon on 8th August, 1959. The Corporation do not bind themselves to accept the lowest or any tender.

W. O. DODD,
Town Clerk,

Town Hall,
Brighton, 1. E5881

BOOKS and PUBLICATIONS

Electronic Engineering

A monthly journal for the professional electronics engineer.

It circulates to 86 different industries all over the world.

When electronic engineering is studied "Electronic Engineering" is read.

Published on last Friday of preceding month.

Price 3/- per copy. 36/- per Annum.

28 ESSEX STREET, STRAND, W.C.2

Telephone : Central 6565

Published by Morgan Bros. (Publishers) Ltd.

EDUCATIONAL

AUTOMATION.—AUTHORITATIVE COURSES are now available in Digital and Analogue Computer Technology, Applied Electronics, Data Processing and Instrumentation up to professional level by home study. Individual enrolment or industrial group scheme enrolments accepted. Syllabuses and prospectus sent on request.—Write (Dept. S.E.8), E.M.I. Institute School of Electronics, College House, Kensington, London, W.8. E145 E

UNIVERSITY OF DURHAM

KING'S COLLEGE, NEWCASTLE UPON TYNE, 1

GEORGE ANGUS STUDENTSHIP

Applications are invited for the above-mentioned Studentship, of the value of £350 per annum, with remission of composition fee, which is available annually for post-graduate research in the Departments of Chemistry, Physics or Mechanical Engineering, as a result of a gift from Messrs. George Angus and Co., Ltd., of Newcastle upon Tyne.

The Studentship is open to graduates of approved Universities, or candidates hoping to graduate in June, 1959. It is tenable for two years, but may be renewed for a third year in special circumstances.

Forms of application and further particulars may be obtained from the undersigned, to whom completed application forms should be returned as soon as possible.

G. R. HANSON,
Registrar of King's College.

E5907 E

TECHNICAL HOME STUDY COURSES

For A.M.I.Mech.E., A.M.I.Chem.E., A.M.I.M.I., A.F.R.Ae.S., C. & G., &c.

OVER 50 FIRST PLACES and more than 2000 Passes have been secured by T.I.G.B. Students at Professional Engineering Examinations. We have a wide range of exclusive Home Study Courses in all branches of Engineering—Mechanical, Electrical, Aeronautical, Automobile, Chemical, Gas, Radio, and Television, Draughtsmanship, &c. Textbooks, blueprints, &c., are provided and, if desired, fees may be paid by moderate instalments.—Write (stating subject of interest) for copy of 110-page Prospectus FREE and without obligation.

THE TECHNOLOGICAL INSTITUTE OF GREAT BRITAIN
(Dept. 76),
29, WRIGHT'S LANE, LONDON, W.8.
E102 E

Classified Advts. continued on page 106

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

ELECTRONICS, covering practical and theoretical aspects, basic principles, industrial applications, electronic apparatus, &c. Guaranteed coaching for Brit.I.R.E., City and Guilds, &c. Study at home under highly qualified tutors.—Write for free book: International Correspondence Schools, 71, Kingsway (Dept. 446A), London, W.C.2. E157 E

SHORT COURSES FOR ENGINEERS.—Lectures, discussions, tutorial classes and practical work on vibration and noise, servo-mechanisms, electronics, hydraulic operation, lubrication, gear design, stress determination, non-destructive testing and other subjects in applied mechanics.—Details from Professor W. A. Tuplin, Applied Mechanics, University, St. George's Square, Sheffield, 1. E5942 E

U.K.A.E.A.

HARWELL REACTOR SCHOOL

Standard Course No. 19

The next Standard course will be held from 31st August to 18th December, 1959, inclusive. The fee for the course is £250 exclusive of accommodation.

Senior Technical Executives Course No. 9

The course will be held from 21st September to 1st October, 1959, inclusive. The fee for the course is 50 guineas exclusive of accommodation.

Application forms and details of both courses can be obtained from:

The Principal,
Reactor School,
Atomic Energy Research Establishment,
Harwell,
Didcot,
Berkshire.

E5908 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

CHIEF ENGINEER required by medium-sized company of Constructional Engineers in Glasgow.

Applications are invited for the above post from Graduate Engineers of 35/45 years of age who have had good workshop experience and several years in a post of major responsibility in the field of constructional engineering and general platework fabrication. The successful applicant will be entirely responsible to the Managing Director for the design and development of all new products and new plant and for the Production Drawing Office.

The post will carry a salary commensurate with qualifications and experience, membership of an excellent Pension Scheme, and Life Assurance and Personal Accident Insurance cover. There will be first-class prospects for further advancement.

Write in confidence, with full personal particulars and details of qualifications and experience, to BOX No. E5868, "The Engineer."

A

CIVIL ENGINEER required by Westminster firm of consulting engineers for position of responsibility. Applicants should not be less than 30 years of age, be A.M.I.C.E. and have had considerable design experience. A variety of interesting projects is in hand including major bridges. Current holiday arrangements honoured. Please apply, giving full particulars of qualifications and past experience.—BOX No. E5947, "The Engineer." A

CIVIL ENGINEERING ASSISTANTS required for Head Office and Site Vacancies in connection with electric power projects in Scotland. Preference for applicants with Engineering Degree or exemption from Parts I and II of Institution examination.—Reply, giving age, qualifications and experience, to JAMES WILLIAMSON AND PARTNERS, 219, St. Vincent Street, Glasgow. E5896 A

COMPRESSOR MANUFACTURERS have vacancy for first-class ENGINEER SALESMAN. Good prospects for the right man. Preference given to candidate with practical knowledge. Full particulars, including education, engineering training and qualifications, previous experience, age and salary desired.—BOX No. E2422, "The Engineer." A

CRANE DESIGN

Engineering Insurance Company has vacancy on its Engineering Staff in Manchester for a qualified Engineer experienced in Crane Design. Age 30–35. Progressive salary. Non-contributory pension and other benefits.—BOX No. E5954, "The Engineer."

A

DESIGN DRAUGHTSMAN required for mechanical design of nucleonic instruments. Pleasant working conditions. Excellent rates of pay.—Apply Chief Draughtsman, ISOTOPE DEVELOPMENTS, LTD., Beenham Grange, Aldermaston, Berks. Tel.: Woolhampton 451. E152 A

SITUATIONS VACANT

DESIGN ENGINEER

Applicants are invited for the following superannuated appointment in the Midland Area for a DESIGN ENGINEER to take complete charge of development of High Speed Turbo machines. Age 30–40. Experience in similar work essential. Engineering Degree desirable. Write in confidence, with full personal particulars and details of qualifications and experience.—BOX No. E5958, "The Engineer."

A

DESIGN ENGINEERS required for North London firm of Mechanical Engineers. Experience in mechanical handling and/or bottling plant an advantage. Initial salary not less than £1050 per annum for first-class men of initiative and responsibility. Canteen facilities. Pension scheme. Apply with full particulars.—BOX No. E5912, "The Engineer." A

DRAUGHTSMAN, with general engineering experience, for work on Compressors and Blowers. State age, experience, and salary required. Canteen facilities and bonus scheme.—George Waller and Son, Ltd., Stroud. Phone: Brimscombe 2301. E2429 A

ENGINEER (about 30 years) required for Consulting Engineers' Office in Manchester; Engineering Degree and/or Corporate Membership of a major Engineering Institution; varied industrial experience an advantage. Technical investigations and reports in matters where litigation is being considered.—BOX No. E5921, "The Engineer." A

ENGINEERS up to about 30 years of age, University trained, with mathematical bias, good Honours Degree and preferably some industrial experience, are invited to apply for a position carrying an attractive salary, pension and good general conditions, as Assistant in a Technical Department of an important engineering organisation. The appointment offers a wide variety of work in association with manufacturers and consultants. Please send full details of academic training and experience.—BOX No. E5922, "The Engineer." A

ENGINEERS required for commissioning and operating duties on large Power Station Water-Tube Boilers in Provinces. Previous water-tube boiler experience desirable, while applicants should have an engineering qualification. Salary: £800 per annum. Adequate hotel and travel allowances. Write fully, stating age, qualifications and experience.—BOX No. E5904, "The Engineer." A

ESTIMATOR required in Rochester area with good general engineering background, preferably with experience in pressure vessels and chemical process plant.—BOX No. E2426, "The Engineer." A

HYDRAULIC DESIGN AND SALES ENGINEER

Sutcliffe Hydraulics, Ltd., of Featherstone Lane, Featherstone, manufacturers of specialist hydraulic equipment, require the services of a competent HYDRAULIC ENGINEER. The work entails the development of existing designs, extension of the Company's range of products and the selling of specialist hydraulic systems and products. Previous sales experience an advantage but not vital, but good general education and sound engineering training is essential. The position offers an excellent opportunity for advancement with a small progressive company, which is a member of a larger group. A four-figure starting salary will be paid depending on qualifications and experience. Contributory Pension Scheme.—Please write giving details of age, education, training, qualifications and experience to the Secretary at the above address. E5953 A

INSTRUMENT ENGINEER

A first class opportunity has arisen for an Engineer experienced in the design of electronic and/or pneumatic process control instrumentation, to join a major London Oil Refinery and Petrochemical Engineering Company.

Applicants should have at least H.N.C. with suitable endorsements.

Salary up to £1500 p.a. according to experience. Please write giving full details in confidence.—BOX No. E5946, "The Engineer."

A

RESEARCH ENGINEERS

MECHANICAL ENGINEERS are required by COURTAULDS LIMITED for its Research and Development Organisation in Coventry, to work on a wide variety of process development and pilot plant operations. Applicants should possess a First or Second Class Honours Degree in Engineering, be not more than 26 years of age, and have had not less than 2 years' industrial experience.

Candidates should write for a detailed form of application to the Director of Personnel, Courtaulds Limited, 16, St. Martins-le-Grand, London, E.C.1, quoting reference number D.93. E5941 A

MUNICIPAL MUTUAL INSURANCE, LTD., has vacancies for ENGINEER SURVEYORS in London and Birmingham. Posts are pensionable and permanent to satisfactory candidates who should have served an apprenticeship and have sound practical and theoretical knowledge. Technical qualifications: First Class Ministry of Transport Certificate. Salary: £735–£1060 per annum.—Apply in own handwriting, marking the envelope "Application Engineer Surveyor" and "Private and Confidential," to Chief Engineer, 22, Old Queen Street, Westminster, S.W.1. E5952 A

SITUATIONS VACANT

MANAGER required in Midlands to take charge of Tube Manipulating Department, employing 200 mixed personnel. Must be first-class organiser. Technical experience not quite so important as organising ability. Age limit 45 years of age. Write giving full details of experience, &c.—BOX No. E5957, "The Engineer." A

RESIDENT ENGINEER (CIVIL) required for large industrial site in South Wales. Must have had similar previous experience. Apply in confidence, giving age, details of experience, when available and salary required.—BOX No. E5935, "The Engineer." A

RESIDENT ENGINEER required in West Midlands. Experience in handling large Engineering Construction projects, including Civil Engineering and Plant installation essential.—Apply General Manager, Head Wrightson Colliery Engineering, Ltd., 46, Rutland Park, Sheffield, 10. E5951 A

SENIOR DRAUGHTSMAN required by medium-sized Engineering Company situated in the East Midlands. The work will be both interesting and varied but applicants must have previous centrifugal pump and/or steam turbine experience.—Write immediately for interview, giving brief details of past experience, &c., to the General Manager, J. P. HALL & SONS LTD., Peterborough. E5914 A

STRUCTURAL STEELWORK DESIGNER with a good knowledge of light structures as well as conventional steel design required by Consulting Engineers. Five-day week. Pension Scheme; holiday arrangements honoured.—Apply, stating full details of experience and salary required to BOX No. E2407, "The Engineer." A

TEST ENGINEER, age 21 to 27, with degree H.N.C. or similar qualification in mechanical engineering, required for staff appointment in the Test House of a new Research Division. Work involves design of test apparatus and supervision of tests of friction material for automotive and industrial applications. Previous experience not essential, but an interest in motor vehicles is desirable. A generous pension scheme is available. The Research Division is situated in a pleasant rural area of the Peak District.—Applications, which will be treated in strictest confidence, should state age, qualifications and experience and should be sent to the Personnel Manager, Ferodo, Ltd., Chapel-en-le-Frith. E5950 A

THE GENERAL ELECTRIC COMPANY LIMITED

Owing to the continued expansion of the Company's activities in the civil nuclear field, both in the United Kingdom and recently in Japan, additional staff is required in the Reactor Heat Transfer Section.

The Section is part of the Research and Development Department and is concerned with the following activities:—

(a) Design and improvement of reactor fuel elements of present and future types.
(b) Evaluation of temperature profiles within reactor structures, pressure vessels and other equipment.
(c) Solution of novel problems of gas kinetics associated both with reactor cores and with charge-discharge mechanisms.

Extensive laboratory facilities are available and applicants who are keen on experimental work will find ready co-operation from existing laboratory technicians. A digital computer is available for the numerical solution of theoretical work and for data reduction.

The following staff are required:—

1. Senior Graduates, preferably with higher Degrees in Heat Transfer or with several years' research or development experience.
2. Graduates in Mechanical or Chemical Engineering, Physics or Applied Mathematics, both for theoretical and experimental work.
3. Engineers with H.N.C. or H.N.D., with experience in experimental work.

Applications, which will be treated as confidential, should be made in writing, giving details of experience, to Personnel Manager (DWB/5), The General Electric Company Limited, Erith, Kent.

E5944 A

TECHNICAL SALES REPRESENTATIVE

A vacancy occurs in the Manchester Office of a Clydeside Firm engaged in the manufacture of Auxiliary Machinery. Applications are invited from men between 25 and 35 years of age, with good personality and a capacity for original creative thinking. To be Apprentice-trained and hold H.N.C. or equivalent. Duties will be concerned with Market problems and technical representation within a prescribed area. A comprehensive training will be given prior to assuming responsibilities. The position offers excellent prospects with a progressive salary scale and there is a Superannuation Scheme in operation.—Write, 1553 Wm. Porteous and Co., Glasgow.

E5893 A

WANTED,—SENIOR JIG AND TOOL DRAUGHTSMAN and MACHINE TOOL DRAUGHTSMAN, by company in the South Coast Area. Experience in machining light alloys and knowledge of hydraulics and pneumatics an advantage. Write, stating age, details of experience, qualifications and salary required.—BOX No. E5870, "The Engineer." A

WANTED,—PRODUCTION ENGINEER required for Engineering Department of a company situated in the South Coast area, manufacturing specialised components for the motor industry. Wide experience of production engineering essential. Some knowledge of time and motion study and works planning an advantage. Write, giving age, details of experience, qualifications and salary required.—BOX No. E5871, "The Engineer." A

YOUNG ENGINEER required for training in centrifugal pump design. Applicant should have good knowledge of hydraulics. Electrical design experience desirable but not essential. Good Prospects for suitable applicant. Near S.E. London district.—BOX No. E5948, "The Engineer." A

SITUATIONS VACANT

A. MONK & COMPANY
LIMITED
WARRINGTON, LANCS.

REQUIRE SENIOR AND JUNIOR SITE ENGINEERS.

Applications invited from those who are experienced in the various duties and responsibilities associated with these positions.

Full details of age, experience, etc., to Mr. H. Hudson, Personnel Department, Padgate, Warrington.

E5938 A

WATER-TUBE BOILER PLANT DESIGN

STAFF VACANCIES

(a) Senior and Junior Design Engineers for Proposal and Contract work on Water-Tube Boiler Plant. Previous experience on Water-Tube Boiler design preferable but not absolutely essential. Minimum qualifications are an engineering degree and/or A.M.I.Mech.E., while starting salary will be in the range £650 to £1150 p.a., dependent upon qualifications and experience. The work is interesting and varied and covers a wide field of heat-transfer applications.

(b) Proposal Draughtsman for interesting work on complete Water-Tube Boiler installations. Applicants should have some previous experience on Water-Tube Boiler Construction and layout. Salary according to experience but not less than £15 per week.

Five-day week, Pension Scheme. Staff Dining Room.

Write, Staff Manager,
FOSTER WHEELER, LTD.,
3, Ixworth Place,
London, S.W.3. E5782 A

JOHNSON, MATTHEY & CO., LIMITED,

DESIGN ENGINEER

Aged 23/33, with good drawing-office experience, is required for a Chief Mechanical Engineer's office in Central London. A sound practical training and knowledge of engineering services is essential.

The work entails handling projects from the drawing-board through to construction and running in for production.

Conditions of service include free lunches and an annual bonus, also a contributory pension scheme. Salary according to age, qualifications and experience.

Write, giving full details of age, qualifications, experience, &c., to the Secretary, Johnson, Matthey & Co., Limited, 78, Hatton Garden, London, E.C.1.

E5738 A

TECHNICAL WRITER

Applications are invited for a position as Technical Writer in the Publicity Department of a large electrical engineering works in the Birmingham area. The work is varied and interesting and the position carries good prospects and salary.

Experience in the preparation of engineering publications and articles for the technical press is essential. Applicants should be between 30–35 years of age and preferably hold an electrical Engineering Degree or its equivalent.

Replies, which will be treated in strict confidence, should give full details of education and experience and should be addressed in the first instance to:—

The Secretary,
BOX No. 72,
Stowe & Bowden, Ltd.,
19, Cursitor Street,
London, E.C.4.

E5925 A

SITUATIONS VACANT

BICC

TECHNICAL MANAGER

Applications are invited for the position of TECHNICAL MANAGER at the Leigh, Lancs, Works of the Wiring and General Cables Division. The successful applicant will be responsible to the Divisional Chief Engineer for the operation of the Technical Department at these Works, including the development of new products and processes, and the test and quality control services in the Works. The successful candidate should have a degree or equivalent in Science or Engineering, and preferably have some experience in the Rubber Cable Industry. Applications in writing to be submitted to the Manager (Personnel), British Insulated Callender's Cables, Ltd., Surrey House, Temple Place, London, W.C.2.

E5905 A

SITUATIONS VACANT

HEAD WRIGHTSON & COMPANY LIMITED

RESEARCH AND DEVELOPMENT DEPARTMENT

require a GRADUATE MECHANICAL or CHEMICAL ENGINEER to lead a team undertaking research on the steam side of Heat Exchangers for Nuclear Power Stations.

Previous experience of two-phase flow would be an advantage, but engineers with good alternative research experience will be considered.

Applicants should be under 35 years of age, and should write, giving details of training, qualifications and experience, to The Personnel Manager, Ref. RD/28, Teesdale Iron Works, Thornaby-on-Tees.

E5915 A

SITUATIONS VACANT

ELECTRICAL ENGINEER

wanted by leading German manufacturer for German-English translations. Applications are invited from British-trained engineers with a good general education and sound technical training, preferably also with practical experience in the application of electric equipment. Good working knowledge of German is essential. The ability to write clearly and concisely will be expected of candidates. A five-day week is worked, with generous holidays. Favourable housing conditions for permanent staff. Apply, stating age, education, qualifications, experience and salary required, to BOX No. E5790, "The Engineer."

A

SITUATIONS VACANT

GENERAL MANAGER

A well-established and expanding company seeks a General Manager for a division in South Wales engaged in the manufacture of high-quality light and medium engineering products and precision sheet metal fabrication.

Starting salary will be not less than £3000.

This post offers exceptional opportunity to a man aged 40–55, with a first-class educational and engineering background, familiarity with metallurgy and the welding of stainless steel, who has held a senior managerial post embracing co-ordination of production, development and sales.

Write briefly and in confidence.

The Managing Director (RT.32),

EXECUTIVE APPOINTMENTS LIMITED,

78, Wigmore Street, London, W.1.

E5924 A

MECHANICAL ENGINEERS

are required by

the United Kingdom Atomic Energy Authority at Aldermaston.

Post 1. Ref. 2278/25. To be responsible to a senior engineer for the control of an Inspection Section dealing with precision components and assemblies manufactured mainly from special materials.

A knowledge of the practice of Metrology and fundamental inspection is required, together with a sound engineering experience and good personality.

Post 2. Ref. 2279/25. To investigate mechanical problems in the toolroom and precision workshop field; to study the application of new machines and techniques in development and "one off" workshops and to carry out research and develop new methods of machining and manufacture.

Considerable tool room and precision workshop experience is essential.

Qualifications: A recognised engineering apprenticeship is required and A.M.I.Mech.E. or equivalent qualifications.

SALARY: £1345–£1800.

Contributory Superannuation Scheme. A house or substantial assistance with house purchase will become available for married officers living beyond daily travelling distance.

POSTCARDS for application forms to the Senior Recruitment Officer at Atomic Weapons Research Establishment, Aldermaston, Berks. Please quote appropriate reference number.

E5900 A

CALTEX SERVICES, LIMITED

CHEMICAL AND MECHANICAL DESIGN ENGINEERS

Applications are invited for these positions from men under 35 years of age who have Honours Degrees or equivalent in Chemical or Mechanical Engineering and four or more years of subsequent experience in design work connected with pressure vessels, pumping installations, heat exchangers, pipe runs, &c., as encountered in the petroleum refining industry.

The positions are initially in the London Office with probable transfer overseas later, most likely to the Middle East.

The commencing salary would be in accordance with qualifications and experience.

Apply in writing in the first instance quoting "LON" and giving complete details, to:

Caltex Services, Limited,
Caltex House,
Knightsbridge Green,
London, S.W.1.

E5843 A

BRITISH OXYGEN GASES LIMITED

SENIOR ENGINEER

A vacancy has occurred for a Senior Engineer for the

Medical Design and Development Group

of the Company, situated at Harlow.

The successful applicant must fill the following requirements:—

1. Be capable of assessing the technical requirements for and initiating design and development of medical apparatus of the kind made by the Company.
2. Must be able to establish the technical requirements and design parameters for new equipment and be able to discuss these problems with members of the Medical Profession.
3. A knowledge of the physiology of breathing.
4. A knowledge of the problems of pressure and flow-control and/or instrumentation and have experience in the design and development of light mechanical and electronic equipment used in these fields.
5. High intellectual capacity with an ability to analyse, investigate and advise on problems arising in the design and development of equipment used in anæsthesia, assisted respiration and oxygen therapy.

This is a senior position and offers good prospects for the future.

Housing assistance is available if required.

Write, stating full details of age and experience, to:—

Personnel Manager,
BRITISH OXYGEN GASES LIMITED,
Spencer House, St. James's Place, London, S.W.1.

E5929 A

ENGINEERS

KELLOGG

INTERNATIONAL CORPORATION

REQUIRE URGENTLY

TWO SENIOR PROJECT ENGINEERS

Due to continued expansion of activities in the Petroleum Refinery and Chemical Plant fields, Kellogg International Corporation have openings for Two Senior Project Engineers with the necessary experience for handling entire projects from inception to completion. Applications are now invited for these posts which carry salaries commensurate with the considerable background of experience required. Suitable applicants should have the following essential qualifications:

(a) University degree and membership of one of the recognised professional institutions.
(b) Extensive experience in handling project work of a similar nature.
(c) The qualities of drive and energy needed to stimulate all those working with him on his project.
(d) The desire to enlarge his field of experience by keeping in touch with latest developments, coupled with willingness to travel to the U.S.A. and to the many European countries in which Kellogg International Corporation are now operating.

MECHANICAL EQUIPMENT ENGINEER

This is a real opportunity for a top-level man, thoroughly experienced in the selection and specification of oil refinery mechanical equipment, including pumps, compressors, turbines and engines, water equipment plant, refrigeration plant, etc. Engineering degree or equivalent preferred, with sound practical experience in this field.

The position involves, at senior level, liaison with clients and manufacturers and will therefore entail visits in U.K. and to the Continent.

Also qualified and experienced engineers in the following categories.

INSTRUMENT ENGINEERS

B Sc. degree or equivalent preferred, though not absolutely necessary provided candidates have a great deal of practical experience.

HEAT TRANSFER ENGINEERS

First class men holding Engineering Degree, or equivalent, for Heat Exchanger work. Must have at least 5 years' experience on mechanical and thermal designs.

PIPING ANALYTICAL ENGINEERS

Must hold an engineering degree. The work consists of the preparation of piping flow diagrams for process and utility systems. Engineers in these positions will work intimately with the process design of refinery and chemical plants and handle problems of instrumentation, pumping, gas compression, heat exchange and other unit operations. A sound technical background will be required but as it will be necessary for the successful candidates to acquire an understanding of the processes and plants involved, a period of initial training will be allowed for at full salary.

OFFSITE ENGINEERS

Must hold Engineering degree, experienced in design of oil refinery or chemical plant offsite facilities.

Our permanent staff enjoy above average salaries, opportunities for advancement, attractive personnel benefits, good working conditions and an excellent Social Club.

Applications, giving brief details of qualifications and experience, should be addressed in the first place to the Personnel Manager.

KELLOGG INTERNATIONAL CORPORATION
7 - 10, CHANDOS STREET, CAVENDISH SQUARE, LONDON, W.1
(Please quote reference 138/G)

E5920 A

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SITUATIONS VACANT

MSL have been retained to advise on the appointment of a

SALES ENGINEER

to be Assistant to the London Manager of a major engineering company supplying heavy power plant components.

The Sales Engineer will be responsible for selling the company's products and services in London and the South of England and for maintaining liaison between company and client from initial enquiry to completion of contract.

Candidates must have experience of technical sales. A professional qualification in mechanical engineering would be an asset.

Preferred age 28 to 32. Salary and allowances about £1,500 on appointment, pension and life insurance.

Please send brief details in confidence, quoting reference G.1640, to J. G. Smith. In no circumstances will a candidate's identity be disclosed to the company concerned unless he gives permission after a confidential interview at which he will be given full details of the appointment.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E134 A

SITUATIONS VACANT

MSL have been retained to advise on the appointment of a

CHIEF ENGINEER

for a leading firm of civil engineering contractors in the London area. The Chief Engineer will be responsible to the Board for the preparation of designs for new projects and all permanent and temporary work.

The Chief Engineer must be a thoroughly experienced engineer, fully abreast of modern development in constructional work and able to collaborate in the development of new designs and methods of construction.

Candidates must have a degree in civil engineering and be a corporate member of the Institution of Civil Engineers; must have led a technical team for civil engineering consultants or contractors.

Age: 35-45. Salary not under £2,500. Generous pension scheme. Assistance with moving expenses if necessary. Car provided.

Please send brief details in confidence, quoting reference G.1659, to H. A. P. Disney. In no circumstances will a candidate's identity be disclosed to the company concerned unless he gives permission after a confidential interview at which he will be given full details of the appointment.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E156 A

SITUATIONS VACANT

MSL have been retained to advise on the appointment of a

WORKS MANAGER

for a company situated in a pleasant part of Hampshire and engaged on the design and manufacture of high precision equipment for the engineering industry. The company, which has a high reputation, at present employs approximately 200, and occupies modern premises of 35,000 sq. ft. with ample room for expansion.

The Works Manager will be responsible to the Technical Director for the executive management of the factory and will act on his behalf when he is away. He will be expected to take an active part in any future development plans.

Candidates must have attained a position of responsibility as production or works manager and have experience in high precision engineering, with a knowledge of modern control procedures and work study. Professional qualifications in mechanical engineering, although not essential, are desirable.

Preferred age 35-40. Commencing salary will be up to £2,000 according to experience. Attractive non-contributory pension and insurance scheme.

Please send brief details in confidence, quoting reference G.1673, to M. B. Berks. In no circumstances will a candidate's identity be disclosed to the company concerned unless he gives permission after a confidential interview at which he will be given full details of the appointment.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E135 A

SITUATIONS VACANT

WORKS MANAGER

A progressive expanding manufacturing organisation wishes to appoint a Works Manager, age 40/50, for one of their subsidiaries employing about 800 personnel.

Candidates should have had considerable experience in Factory Management and in the field of mass producing medium precision components. The Company making the appointment is anxious to engage a man with drive and initiative, and applicants should be prepared to operate with any one of the subsidiaries within the organisation after serving an initial period with the Parent Company.

Only First-Class men will be considered for this position and preference will be given to candidates who have qualified as a member of either A.M.I.Mech.E. or M.I.P.E. This appointment carries a very attractive salary, together with excellent conditions of service.

Please reply, giving details of age, present salary, experience and qualifications, which will be treated in the strictest of confidence. —BOX No. E2427, "The Engineer." A

ALFA-LAVEL COMPANY LIMITED
require a

TECHNICAL SALES REPRESENTATIVE

for the South Midlands Area, to handle centrifuge, washing equipment and heat exchanger sales to diesel and turbine manufacturers and users, machine shops and the process industries.

Applicants, age group 30–35, should have engineering qualifications to H.N.C. or higher level, and preferably some selling experience in similar fields.

HEAT EXCHANGE ENGINEER

This is a new post at our Brentford Office, requiring an engineer with heat exchange experience for calculation and sales development work with our Plate Type Heat Exchangers in new fields.

Applicants for this interesting position should have a practical and commercial outlook.

Write, giving details of age, education, previous experience and salary expected, to:
Ref. DGG,
ALFA-LAVAL COMPANY, LTD.,
GREAT WEST ROAD,
BRENTFORD, MIDDLESEX.

E5940 A

UNILEVER

have vacancies for

INSTRUMENT ENGINEERS

Applicants should have adequate academic or professional qualifications in electrical engineering or physics and should have design experience in electronics, process control or instrumentation.

INSTRUMENT TECHNICIANS

Applicants should have experience in the commissioning and servicing of instruments and process control equipment.

Applications giving details of training, qualifications and experience should be addressed to Head Office Staff Department (WF 40), Unilever House, Blackfriars, London, E.C.4.

E5789 A

SHORTS

(Light Aircraft Division)

The design team for this newly formed division is now being assembled. It will be under the personal leadership of the head of the Division, and will be small in size, in consequence, members will be expected to undertake a wide variety of duties.

Applications are invited from Engineers who have an interest in light aircraft and who like the idea of hard work in a small group. Vacancies occur for Juniors and Seniors in the following categories:—

Control and Stability Calculations.
Equipment Installation Design.
Mechanical Design.
Performance Prediction.
Power-Plant Installation Design.
Strength and Stiffness Calculations.
Structural Design.
Vibration Analysis.
Weight Prediction and Control.

Attractive salaries will be offered to experienced and qualified applicants and assistance with removals and housing will be available to approved married candidates from Great Britain.

The Company operates a Superannuation Scheme.

All successful candidates will be interviewed personally by Mr. F. H. Robertson, Chief Designer, Light Aircraft Division.

Write in the first place to the:

Staff Appointments Officer,
SHORT BROTHERS AND HARLAND, LIMITED,
BELFAST,
Quoting S.A. 417.

Interviews will be arranged either in London or Belfast.

E5930 A

SITUATIONS VACANT

PLANT INSPECTORS AND CORROSION ENGINEER

APPLICATIONS are invited for these positions from men not over 40 years of age with a degree in Metallurgy or Mechanical/Chemical Engineering and subsequent experience of this type of work in the Oil Industry.

(*a*) LONDON — Plant Inspector/Corrosion Engineer not over 40 years of age with experience both in cathodic protection and inspection of oil refinery plant. Initially with Caltex Services, Ltd., in London with likely transfer to Bahrain later.

(*b*) BAHRAIN — Plant Inspectors (2) not over 40 years of age whose duties would be the physical inspection of refinery equipment and the recommending of replacements and new materials necessary to ensure safe continuous operation of the Bahrain Petroleum Company, Ltd.'s Refinery. A recent graduate willing to train might be considered for one of the Bahrain openings.

The commencing salaries would be in accordance with qualifications, experience and location of work.

The London position carries normal pension plan benefits, lunch vouchers and leaves. In Bahrain the company provides free air-conditioned accommodation and a living allowance with an initial kit allowance, medical attention, paid home and local leaves with passage paid for the former and generous assistance towards fare for latter, and also participation in Pension and provident fund plans.

Apply, in writing, giving full personal particulars and details of experience, quoting "INS" to Caltex Services, Ltd., Caltex House, Knightsbridge Green, London, S.W.1.

E5903 A

NABISCO FOODS, LIMITED

(Formerly The Shredded Wheat Company, Limited)

WELWYN GARDEN CITY, HERTS,

invite applications for the position of

MANAGER OF MECHANICAL DEVELOPMENT

Successful applicant will be a fully-qualified MECHANICAL ENGINEER, with many years of practical experience of mechanical drawing and design of machinery including automatic processing, packaging and similar equipment, part of it in a position of responsibility such as project engineer. He will have a real desire to do, and possess considerable inherent natural ability for original development work, and be capable of organising and directing the work of others, and of collaborating with Production, Engineering and other departments.

The Manager of Mechanical Development will be directly responsible to the Works Director for

1. Increasing the operating efficiency of existing equipment through mechanical improvements installed and tested in actual production ;
2. Introducing economies through reductions in labour by the development of mechanical equipment.

This position carries commensurate salary, progressive salary grade, excellent amenities, and considerable scope in an expanding organisation.

Applicants invited to write, in strict confidence, stating age, educational background, experience, present position and salary to Executive Administrator—Personnel.

E5901 A

DRAUGHTSMAN

UNILEVER LIMITED, at their Food Research Department near Bedford, require a Draughtsman in the Development Division, to work on the design of special purpose machinery and of Pilot Plant equipment in connection with the food industry. Candidates must have served a full engineering apprenticeship and possess a good Higher National Certificate. The preferred candidate will be about 25 years of age and have completed National Service commitments.

Salary will be paid according to age and experience and there is a comprehensive superannuation scheme.

Please apply to : The Staff Officer (IDM.71), Unilever Limited, Colworth House, Sharnbrook, Bedford.

E5849 A

BRITISH PITOMETER COMPANY, LIMITED,

invite applications for the following posts at their works in Park Royal, London :—

DEVELOPMENT ENGINEER, interested in applying new or improved ideas to flow-measuring instruments and recorders, also to level indicators, transmission and control systems, &c. A background knowledge of small mechanisms and/or electrical measuring instruments would be advantageous, but is not essential. The post is a new one and offers scope for initiative.

SALES ENGINEER, who would be expected to discuss flow measurement and allied projects with clients and be responsible for the preparation of estimates, tenders and specifications. There is every prospect of rapid advancement for the right man.

DRAUGHTSMAN/DESIGNER, to engage on detailed design and development of instrumentation coming generally within the above category. He would be expected occasionally to take part in field trials and other outside duties.

There is a life insurance and pension scheme. Applications, giving age, particulars of career and salary required, should be addressed to the Chief Engineer, British Pitometer Co., Ltd., 52, Minerva Road, Park Royal, N.W.10, and will be treated in strict confidence. E5939 A

SITUATIONS WANTED

CANADA.—Scotch Engineer with wide experience in Canada, wishes to join British company opening a branch or requiring representation in this country. Preferences, steel, metallurgical, mining plant, industrial furnaces and auxiliary equipment. Reply in strict confidence.—BOX No. E2421, "The Engineer." B

GRADUATE (Mod. languages), now design-draughtsman (Mech.), seeks technical translation—French, Italian, Spanish into English.—BOX No. E2424, "The Engineer." B

MISCELLANEOUS

WORKS DOCKETS, TIME SHEETS, COSTING SHEETS, STORES FORMS AND EVERY DESCRIPTION OF PRINTING for the Engineering and Allied Trades. Quotations by return. Prompt delivery.—J. H. Yeomans (Printers), Ltd., 4, Sunbeam Road, London, N.W.10 (Elgar 7928/7800). E5902 I

DAVIES INVESTMENTS LIMITED, Bankers, still offer 7½ per cent. on sums £20 to £500 (withdrawal on demand) with extra ½ per cent. on each £500 unit.—Details from Investment Dept., E.R. Davies Investments, Ltd., Danes Inn House, 265, Strand, London, W.C.2. E149 I

MISCELLANEOUS

D. HEPBURN

Professional Engineer

(Registered in Ontario)

Mechanical, Electrical and Agricultural

Available for Consultations, Designs, Plant Layouts, Supervision of Installations, Translations from Technical French and German to English. Will travel anywhere in Free World.

Postfach, Basel 2, Switzerland.

E153 I

BUSINESS OPPORTUNITIES

BELGIAN METALLURGIC FACTORY of middle importance wants to enter into connection with British firms desirous to collaborate or to take an interest in manufacturing material in European Common Market. Write to Journal.—BOX No. E5750, "The Engineer." O

REMPLOY SPONSORSHIP SCHEME.—Send for details which show an attractive proposition to manufacturers.—Write to the Managing Director, Remploy, Ltd., 25-28, Buckingham Gate, S.W.1 or telephone VICtoria 6621 (12 lines). E155 O

MEDIUM HEAVY ENGINEERING COMPANY in Midlands wishes to contact firms who are looking for capacity for the complete manufacture of contractors' plant or similar machinery.—BOX No. E2430, "The Engineer." O

FOR HIRE

LATTICE STEEL. Erection Masts (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1. ('Phone, SLOane 5259). E103 K

SUB-CONTRACTING

CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process ; sample castings treated ; A.I.D. approved. —Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone Byron 1178). E109 MW

KELLERING AND CAM PROFILING capacity up to 8ft. by 6ft. or 6ft. diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone : Knottingley 2743/4). E116 MW

HEAVY AND MEDIUM PLATE AND PRESS SHOP CAPACITY AVAILABLE, London area. 14,000 sq. ft. erecting bay equipped with 40 tons overhead crane with 32ft. lift. Equipment includes 12ft. by 450-ton brake press 12ft. by ¼in. capacity shear and arc welding equipment. Please send details of enquiries.—BOX No. E5945, "The Engineer." MW

MACHINERY Etc. WANTED

WATER COOLER, 7000 g.p.h., 750,000 B.Th.U.'s/Hr. from 50 deg. C.—BOX No. E2423, "The Engineer." F

FLOOR TYPE SLAT CONVEYOR, 4ft. wide, 150ft. long, intermittent running 22-25 f.p.m., total load 136 tons, sizes approximate.—Details to The Buyer, Universal Asbestos Manufacturing Co., Ltd., Tolpits, Watford, Herts. E5926 F

ROLLING MILL DRIVE, 1000 h.p. reversing 0/150 r.p.m. Mill Motor together with suitable motor generator for Ward Leonard control.—BOX No. E2428, "The Engineer." F

FOR SALE

FOR SALE OR HIRE

Butters 10-ton Electric Derrick Crane, 120ft. jib. 2-motor type. New 1955. Complete with 25ft. Towers and Bogies.

Fowler 150 h.p. 0-4-0 Diesel Locomotive, 4ft. 8½in. gauge. Fully reconditioned.

ABELSON AND CO. (ENGINEERS), LTD., Coventry Road, Sheldon, Birmingham, 26. 'Phone : Sheldon 2424. E5894 G

ONE 10-TON ELECTRIC LUFFING AND TRAVELLING JIB CRANE by Cowans, Sheldon and Co., Ltd. 50ft. maximum radius of jib, maximum lift above rail level 45ft., motorised 230 volts d.c.

JOHN CASHMORE, LTD., NEWPORT, MON. E154 G

CALCIUM SILICIDE.—Finely ground CALCIUM SILICIDE—for nodular iron, exothermic compositions, etc. (now being successfully used by several foundries) at prices which save you money.—TOXANE, LTD., 47, High Street, Edgware, Middlesex. EDGware 6666. E2412 G

FOR SALE

FRED WATKINS (ENGINEERING) LTD.

STEAM BOILERS.—Cochrane Vertical (New), 8ft. 6in., 8ft., 7ft. 6in., 7ft. and 6ft. in dia., 100/150 lb. w.p. ; reconditioned 8ft. 6in. down to 3ft. dia. ; Economic 4ft. to 11ft. 6in. dia., including new 7ft. and 8ft. dia., 150, 180 and 200 lb. w.p. ; 300 reconditioned Vertical Crosstube, all sizes.

AIR COMPRESSORES.—Two Belliss & Morcom 2500 c.f.m., 100 p.s.i., 550 h.p. motors ; also Broomwade 500, 400, 300, 200 and 130 c.f.m., all motorised ; and several others of various makes and capacities.

200 AIR RECEIVERS, stocked up to 9ft. dia., 100 to 500 lb. pressure.

ELECTRIC MOTORS.—150 Totally Enclosed and Flameproof Motors up to 100 h.p.

MOBILE ROAD CRANES.—10-ton Lorain lorry mounted, 30ft.–70ft. extendible jib ; 10-ton 33 R.B. track mounted, 40ft. jib ; 8½-ton Ransomes Diesel/Electric, 21ft. jib ; 6-ton Coles Diesel/Electric, pneumatics, new 1948 (2) ; 6-ton Coles Diesel/Electric, solids ; 4-ton Coles Diesel/Electric, solids, 1945 ; 4-ton Jones KL44, diesel, 1950 ; 3-ton Jones "Super 40" diesel, pneumatics (3).

OVERHEAD CRANES.—40-ton Babcock, 40ft. span, 400/3/50, "Goliath" ; 30/5-ton Adamson, 42ft. 3in. span, 400/3/50 ; 20/6-ton Vaughan, 42ft. 3in. span, cab type (6) ; 20-ton King, 42ft. 3in. span, 400/3/50 ; 15-ton Morris, 35ft. span, hand operated ; 10-ton Morris, 45ft. span, 36ft. lift ; 10-ton Morris "Goliath," 40ft. span, 400/3/50 ; 10-ton Vaughan, 23ft. 6in. span, 400/3/50 ; 10-ton Vaughan, 21ft. span, 44ft. lift ; 7½-ton Wharton, 25ft. span, 400/3/50 ; 5-ton Henderson, 24ft. 7in. span, 1946 ; 5-ton Morris, 58ft. span, hand operated ; 5-ton Royce, 2-motor crab, 440/3/50 ; 5-ton King, 29ft. 3in. span, power hoist, hand travel ; 5-ton Morris, 28ft. 6in. span, power hoist, hand travel ; 4-ton Morris, 19ft. span, 220V, d.c. (3) ; 3-ton Adamson, 48ft. span, 400/3/50 ; 2-ton Adamson, 34ft. span, 400/3/50 (2) ; 2-ton Morris, 18ft. span ; 2-ton Vaughan, 27ft. 6in. span, 2-motor ; majority of the above are unused.

DERRICK CRANES.—7-ton Rushworth hand 30ft. jib ; 5-ton Wilson Electric, 70ft. jib ; 1½-ton Anderson Grice, hand, 40ft. jib.

RAIL CRANES.—18-ton Brownhoist, steam, 50ft. jib ; 10-ton Coles steam, 40ft. jib ; 10-ton Grafton, 34ft. jib, diesel conversion ; 8-ton Wilson steam, 35ft. jib ; 5-ton Grafton, 35ft. jib, diesel conversion ; 5-ton Smith, 50ft. jib (2) ; 5-ton Cowans Sheldon, 50ft. jib.

LOCOS.—Fowler diesel, 150 h.p. (2) ; Ruston diesel, 80/88 h.p., new 1942 ; Bagnall 14in. by 22in., two oil fired, one coal ; Peckett steam, 7in. by 12in., 1941 ; also 3 miles track, 24in. gauge, Bogies, Turnouts, &c.

STEEL PIPING.—50,000ft., 2in. Galvanised, new ; 60,000ft., 3in. black, new ; 5000ft., 8in. seamless ; 1000ft., 12in. seamless ; 500ft., 14in. seamless ; 400ft., 18in. riveted ; 280ft., 21in. o.d. welded flanged ; 3800ft., 21in. seamless flanged ; 500ft., 24in. riveted ; 1450ft., 27in. o.d. welded flanged ; 216ft., 48in. riveted ; 216ft., 60in. riveted.

CAST IRON PIPES.—Large stocks all sizes up to 24in. flanged and s.s. Immediate delivery.

VALVES.—Exceptional Surplus Ministry Lot New Stainless Acid Cocks and Valves, over 5000, immediate delivery, below makers' prices. Large stock all sizes, Parallel Slide Sluices, Gunmetal, Reducing and Check Valves. List on request.

STORAGE TANKS.—300 cylindrical and rectangular up to 12,000 gallons, for oil and petrol, also sectional steel and cast iron up to 50,000 gallons.

MACHINE TOOLS.—Scriven Plate Bending Rolls, 14ft. by ¾in. ; Robertson Straightening Rolls, 8ft. 6in. by ¾in. ; Berry Bending Rolls, 7ft. by ½in. ; Tangye 200-ton Hydraulic Vertical Straightening Press, 15ft. by 3ft. table ; Herbert 3ND Miller, 61in. by 15in. table ; Pels Punch and Shears, ¾in. capacity ; nine new 2 cwt. and 1 cwt. Pneumatic Hammers ; Bliss 14T Tapering Press ; Bonn Hydraulic Tube Bender up to 20ft. by 4in. bore ; Bigwood geared Bending and Straightening Machine up to 12in. by 6in. R.S. Joists ; two 40kVA. Spot Welding Machines ; Wire Drawing Machine, 3 die up to ¾in. copper ; 50kW. Electric Furnace, 1000 deg. Cent., chamber 54in. by 30in. by 21in.

SLING ENGINEERING WORKS

COLEFORD, GLOS.

'Phone : Coleford 2271/2. E106 G

TWW

NEW OLDFIELD & SCHOFIELD 15in. centres, TYPE C, S.S. and S.C. GAP BED LATHE, on 16ft. 6in. bed, admits 10ft. between centres.

NEW MITCHELL OF KEIGHLEY 14½in. centres, S.S. and S.C. GAP BED LATHE, on 14ft. bed, admits 7ft. 9in. between centres.

NEW MITCHELL OF KEIGHLEY 12½in. centres, S.S. and S.C. GAP BED LATHE, on 12ft. bed, admits 6ft. 9in. between centres.

NEW GRANOR 11in. centres, S.S. and S.C. GAP BED LATHE, on 14ft. bed, admits 9ft. between centres.

NEW MITCHELL OF KEIGHLEY 10½in. centres, S.S. and S.C. LATHE, on 10ft. bed, admits 5ft. 5in. between centres.

NEW WOODHOUSE & MITCHELL SERIES 85, 10½in. centres, S.S. and S.C. GAP BED LATHE, on 10ft. bed, admits 6ft. between centres.

All above motorised for 3 phase A.C. supply.

THOS. W. WARD LTD.

ALBION WORKS - - - SHEFFIELD

'Phone : 26311. 'Grams : "Forward."

E216 G

NISSEN TYPE HUTS for sale. Prompt despatch of 16ft., 24ft. and 30ft. wide huts ; also "Romney" Huts, 35ft. wide, and "Blister" Hangars, 86ft. 6in. and 91ft. wide. These buildings are in various lengths and comprise steel framework with galvanised corrugated steel sheeting.—Full details from Dept. 115, J. Thorn and Sons, Ltd., Brampton Road, Bexleyheath, Kent (Tel. : Bexleyheath 305).

E113 G

Classified Advts. continued on page 110

FOR SALE

600

ALTERNATOR SETS

Four 400 h.p. Rolling Mill Drives by ENGLISH ELECTRIC CO., 440 volts, 3 phase, 50 cycles supply; each comprising slipring motor, 738 r.p.m., coupled to gearbox giving final 30 r.p.m., with barring motor, control gear, oil pumps, oil cooler. Transformers available for 11,000/415 volts with switchgear.

2500kW., 440 volts, 3 phase, 50 cycles pass-out/condensing Steam Turbo Alternator Set by BRITISH THOMSON HOUSTON; 255 p.s.i. initially, capable of extracting 55,000 lb or more steam/hour at pressures up to 35 lb. Turbine also designed to operate fully condensing and is complete with ancillaries and switchgear.

3000kW., 6600 volts, 3 phase, 50 cycles pass-out/condensing Steam Turbo-Alternator Set by METROPOLITAN VICKERS, date 1948; turbine designed to work with steam at 340 p.s.i., 600 deg. F. total temperature, and to pass out up to 60,000 lb steam/hour at 40 p.s.i. Makers confirm that it is also suitable to operate double pass-out at the two pressures shown. Turbine is built on to its surface condenser at floor level and is complete with pump and ancillaries, alternator complete with switchgear to form a complete installation as at present arranged.

5000 c.f.m., 12 p.s.i., BELLISS & MORCOM 2-stage Turbo Blower, mounted on bed plate and direct-coupled through reduction gear ratio 7·3 : 1·5 to 400 h.p. Synchronous Motor by Lancashire Dynamo Co., 400 volts, 3 phase, 50 cycles, 1500 r.p.m., and complete with control gear.

GEORGE COHEN,

Sons and Co., Ltd.,
Wood Lane, London, W.12.
(Shepherds Bush 2070)
Stanningley, Nr. Leeds.
(Pudsey 2241). E204 G

FOR SALE

ORMEROD 26IN. STROKE SLOTTING MACHINE

Table 50in. square with power feeds and rapid traverses in all directions; late type machine in first-class condition.

F. J. EDWARDS LTD.,

359–361, EUSTON ROAD,
LONDON, N.W.1.
EUSton 4681 and 3771. E5898 G

FOR SALE

VALES PLANT REGISTER LIMITED

OFFER FOR IMMEDIATE SALE

CRANES

NEALS 15 cwt. PORTABLE, 3 jibs, Lister diesel, pneumatics. 1957/8. £600.
NEALS 1-ton "D" MOBILE, 30ft. swan-neck, Ruston engine, pneumatics. £750.
JONES "Super 20" MOBILE, 16ft. jib, petrol solids. £275.
JONES "Super 22" MOBILE, 24ft. jib, pneumatics and grab. £650.
NEALS "NM" 2-ton MOBILE, 35ft. jib, Ruston engine, pneumatics. £1450.
COLES 2½-ton EMA MOBILE, 16ft. jib, Perkins engine, pneumatics. £1050.
ANDERSON GRICE 3-ton Electric DERRICK, 120ft. jib, S.L.I. £1500.
JONES KL44 4-ton MOBILE, 40ft. jib, Ruston diesel, pneumatics. 1954. £2550.
ANDERSON GRICE 5-ton Electric DERRICK, 120ft. jib, New 1946. £2600.
COLES THORNEYCROFT 5-ton LORRY MOUNTED Mk. 7, Series 7, 30ft. jib, rope derricking. £2500.
NEALS 4/6-ton "QM" MOBILE, Ruston engine, pneumatics. 1953. £2500.
BUTTERS 5-ton Single Motor Electric DERRICK, 85ft. jib. £1750.
COLES 6-ton MOBILE, 21/30ft. jibs, Perkins engine, pneumatics. £3300.
BUTTERS 7-ton, 2-motor Electric DERRICK, 120ft. jib. £2975.
RUSHWORTH 7-ton Hand DERRICKS, 30ft. lattice jibs. £245 each.
MICHIGAN TMCT 16 7½-ton LORRY MOUNTED crowd shovel, dragline and 30ft. jib, Buda diesel, pneumatics. £3300.
BUTTERS 10-ton Steam DERRICK, 120ft. jib, with bogies and oil-fired boiler.
COLES 12½-ton Fully MOBILE, 80ft. jib. £4750.

FOR A COMPREHENSIVE LIST OF PLANT FOR SALE AND HIRE—SEND FOR VALES FREE PLANT REGISTER.

Further details: 14, Lower Grosvenor Place London, S.W.1.
Telephone: VICtoria 7531, 3501, 8080, 9886 (15 lines). E107 G

FOR SALE

RAILWAY TURNTABLE
For Sale.—Mundt type standard gauge turntable, 65ft. long, carrying capacity 150 tons approx.
WATER CRANE
3000 gallon water crane.
TURNOUTS
Twenty 1 in 8 turnouts in 75 lb. F.B. rail; interchangeable to suit L.H. or R.H.
All these items are in excellent condition.

Apply: EAGRE CONSTRUCTION CO., LTD., East Common Lane, Scunthorpe, Lincs. ('Phone: 4513). E150 G

FOR SALE

Edwards

TAYLOR & CHALLEN No. 562 Double-Sided Geared Power Press, balance drive, complete with automatic press guard, arranged motor drive for 400/440/3/50, pressure exerted approximately 100 tons, stroke 2in., between uprights 24in., tee-slotted bed 22in. by 20½in., weight approximately 71 cwt.
New Type SKG.203 size Motorised Geared Open-Ended Guillotine Shearing Machine, Undercrank type, arranged motor drive for 400/440/3/50, capacity mild steel 80½in. by ¼in., length of blades 83½in., depth of gap in open ends 6in., treadle-operated clutch, weight approximately 40 cwt.
NEW MUBEA All-Steel Construction Bar and Angle Shear, flywheel and gears are situated inside the body, which gives a clean appearance to the machine and also protection to the moving parts, arranged motor drive for 400/3/50, Model KSF100, round bars 2in., square bars 2in., flat iron 10in. by ½in., 5½in. by 1in., angles up to 4in. by ½in., 5in. by 0·425in., tee iron 5in., beams 6in., channels 6in., approximate weight 4400 lb.
BESCO Heavy Universal Edging, Bending and Folding Machine, capacity 8ft. 2in. by 16 gauge, fitted with centre supporting leg to strengthen bottom bed, an angle stop is also fitted for repetition work, the machine is complete with one sharp edge blade only, blades are quickly interchangeable, an adjustable back gauge is also supplied, weight approximately 3100 lb.
Double-Sided Friction Screw Press, with self-contained vee rope motor drive suitable for 400/440/3/50, motor mounted on adjustable platform, hand lever control, fitted with Udal air-operated, operator's guard, pressure 50 tons, stroke 9in., between uprights 15½in., approximate weight 71 cwt.
QUICKWORK No. 321 Motorised Rotary Shearing Machine, with circle cutting attachment, arranged motor drive for 400/440/3/50, capacity 14 S.W.G. mild steel, depth of shear throat 30in., diameter of cutters on inclined shafts 2in., cuts circles from 6in. to 60in. diameter, depth of gap in bow 38½in., weight approximately 18 cwt.

Photographs of the above are available.

Very favourable Hire Purchase terms can be obtained.

MACHINE TOOLS, NEW AND USED,
Of Every Description. Attractive Prices.

F. J. EDWARDS LTD.,

359–361, EUSTON ROAD,
LONDON, N.W.1.
Telephone: EUSton 4681–3771.
And at
LANSDOWNE HOUSE, 41, WATER STREET,
BIRMINGHAM, 3.
Telephone: Central 7606–8. E207 G

FOR SALE

L. STORHAUG AND PARTNERS, LTD.

One 3-drum Yarrow type BOILER, 100,000 lb. steam per hour—unused.

Two Ruston and Hornsby DIESEL GENERATING SETS, 300kW., 220 volts, 428 r.p.m.

One 200kVA., 400 volts, 3-ph., 50 cycles, Mirrlees DIESEL GENERATING SET.

25, FINSBURY COURT,
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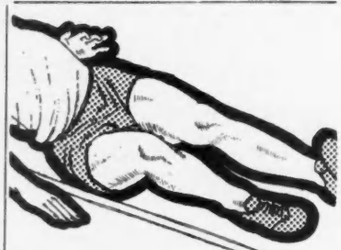
E147 G



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		Main Location	*Auctioneers*
June 2–5	**Vehicles, lifting and earth-moving equipment, motor cycles,** etc.	M.O.S. Storage Depot, **Ruddington, Notts.**	**WALKER, WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 54272.)
June 3	**Miscellaneous stores,** including : greatcoats, denim blouses ; pullovers ; drawers ; old blankets, canvas, tentage, hessian and webbing ; waterproof sheets ; web packs and haversacks ; old batteries ; cable ; electrical, wireless and telephone spares ; charging sets ; generators ; stackers ; storehouse trucks ; radar trailers ; handtools ; ironmongery ; paint ; weighing machines ; mess tins ; water bottles ; metal racking ; office safes ; furniture, etc.	Northern Command Ordnance Sub-Depot, **Barlow, Nr. Selby, Yorkshire.**	**BARTLE & SON** (Dept. L), 50–52, Merrion Street, Leeds, 2. (Tel.: 2.0898).
June 10	**Machine tools and miscellaneous stores.**	Technical Stores Depot, **Old Dalby, Leics.** (Sale at Melton Mowbray.)	**SHOULER & SON** (Dept. L), 1, Norman Street, Melton Mowbray, Leics. (Tel.: 3081.)
June 16–17	**Machine tools and miscellaneous stores.**	M.O.S. Storage Depot, **Byley, Nr. Middlewich, Cheshire.** (Sale at New Islington Public Hall, Ancoats, Manchester.)	**J. H. NORRIS & SON** (Dept. L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.)
June 19	**Miscellaneous stores.**	Returned Stores Group, **Reed Hall, Colchester, Essex.**	**FENN, WRIGHT & CO.** (Dept. L), 146, High Street, Colchester, Essex. (Tel.: 3171.)
June 25–26	**Machine tools and miscellaneous stores.**	Hawker Aircraft Factory, **South Shore, Blackpool.**	**LESLIE A. BUTSON** (Dept. L), 16, Birley Street, Blackpool. (Tel.: 21073.)
June 30–July 2	**Machine tools and miscellaneous stores.**	M.O.S. Storage Depot, **Royal Arsenal, Woolwich, S.E.18.**	**FULLER, HORSEY, SONS & CASSELL** (Dept. L), 10, Lloyd's Avenue, E.C.3. (Tel.: Royal 4861.)

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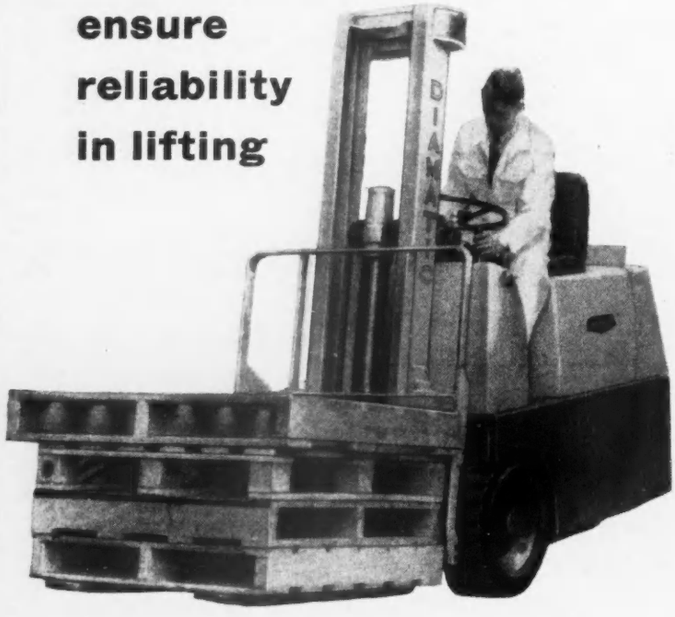

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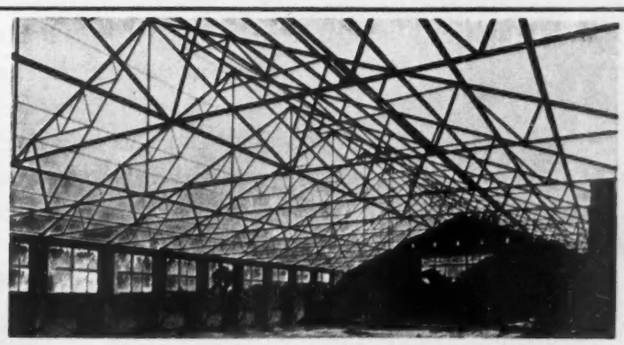

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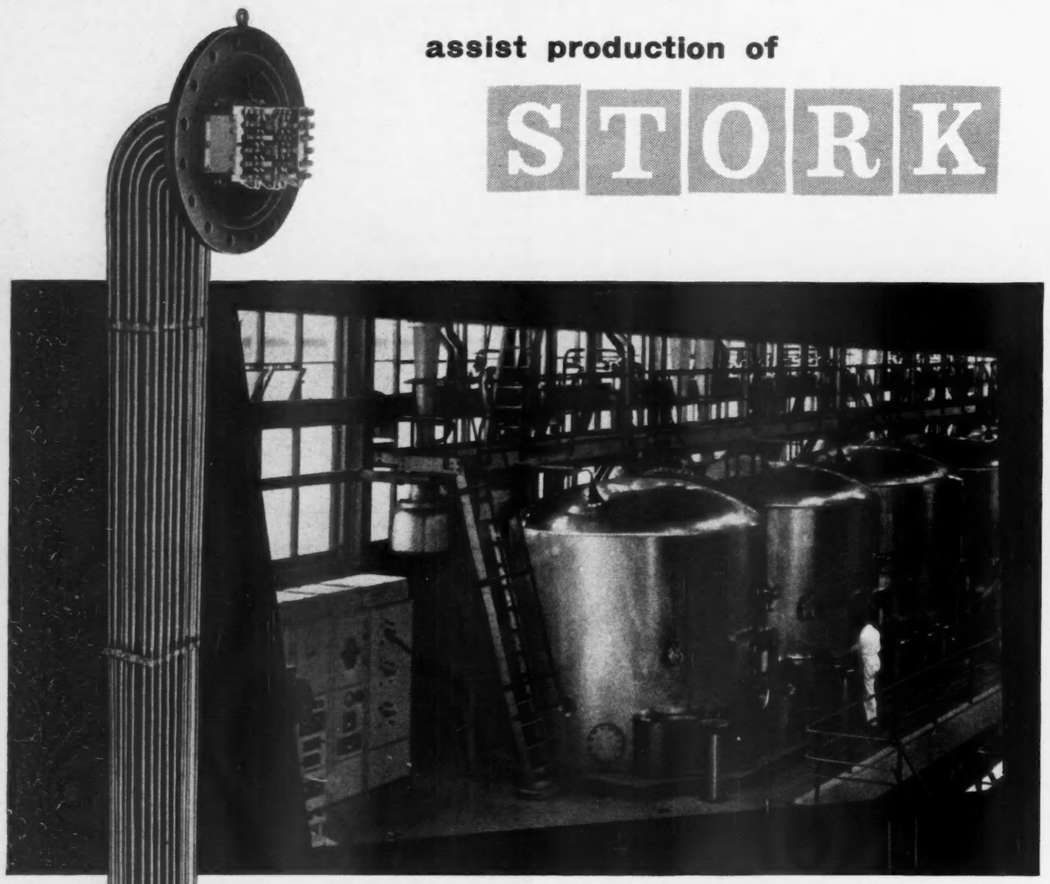

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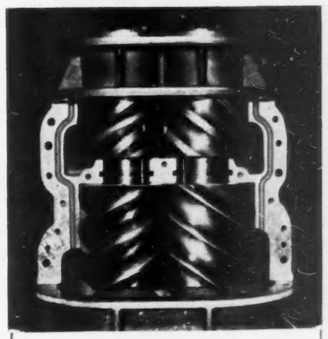

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Buttercups at Richborough

Two 860,000 lb/hr "Etaflo" water tube boilers are being built by John Thompson for the C.E.G.B.'s Richborough generating station.

The "Buttercups"—yellow helmeted John Thompson erectors—are conspicuous on power station and industrial sites all over the country, and in many territories overseas. They instal water tube boilers, coal and ash handling plant, stokers, water treatment plant, steelwork and pipework, galleries and ladders—all products of companies of the John Thompson Group. John Thompson Water Tube Boilers Ltd. design, manufacture and instal complete steam-raising plant for power generation and industry, and is now in the forefront of those who have extended their existing facilities to Nuclear Power Plant manufacture.

JOHN THOMPSON WATER TUBE BOILERS LTD **WOLVERHAMPTON**

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